

Basic Radiation Training

Emergency Workers and Personnel & Equipment Monitors

State of Alabama

Office of Radiation Control

Alabama Department of Public Health

334.206-5412

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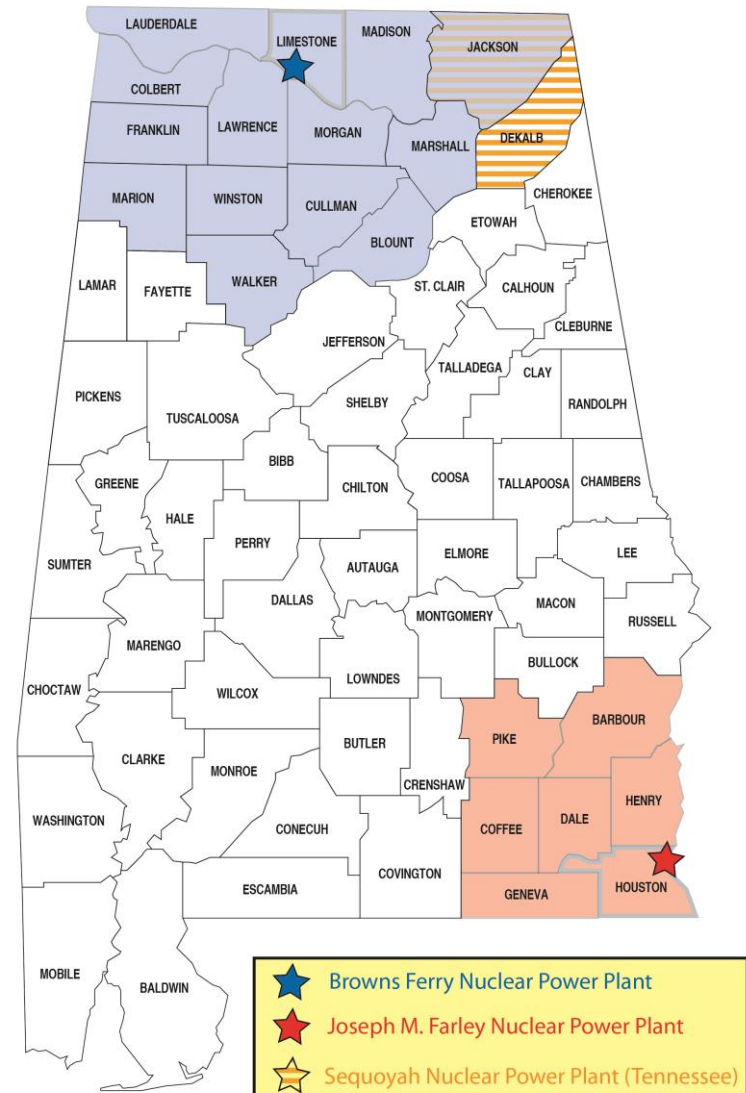
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Nuclear Power Plants

- Alabama: There are two active nuclear power plants
- Training and Equipment
- 10-mile EPZ
- Browns Ferry : There are four risk counties and one host county
- Joseph M. Farley: There are two risk counties



Radiological Emergency Preparedness (REP) Plan

- Plan for OFF-SITE emergency response & recovery
- Utility is responsible for ON-SITE emergency response & recovery



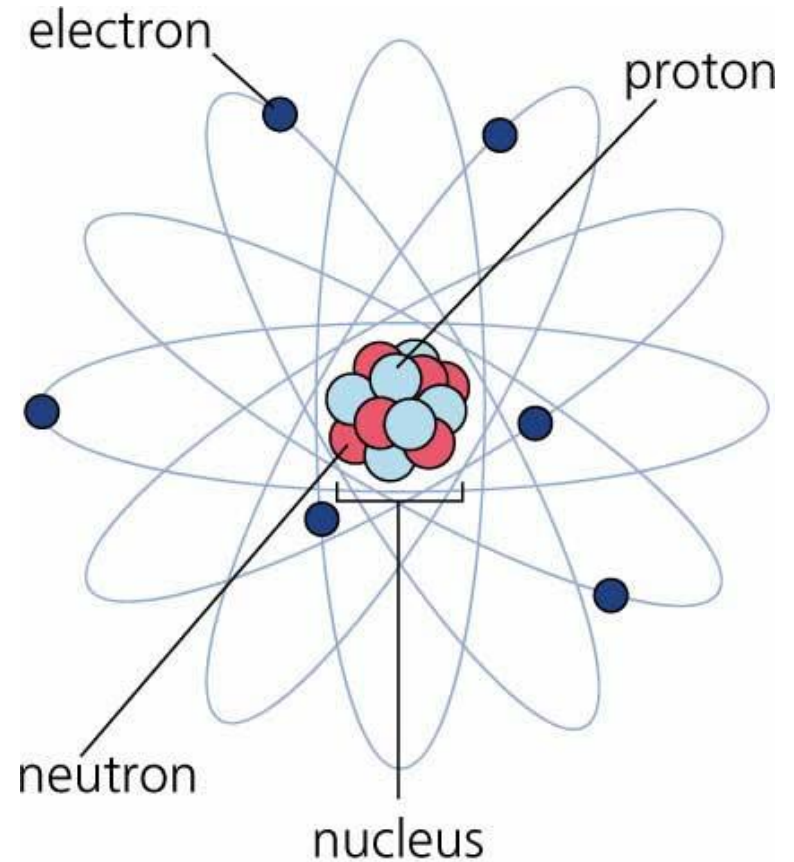
Emergency Classification Levels

- Notification of Unusual Event
- Alert
- Site Area Emergency
- General Emergency



Radiation

Radiation is energy that travels in the form of waves or high-speed particles. It occurs naturally in sunlight and sound waves. Man-made radiation is used in X-rays, nuclear weapons, nuclear power plants, and cancer treatment.

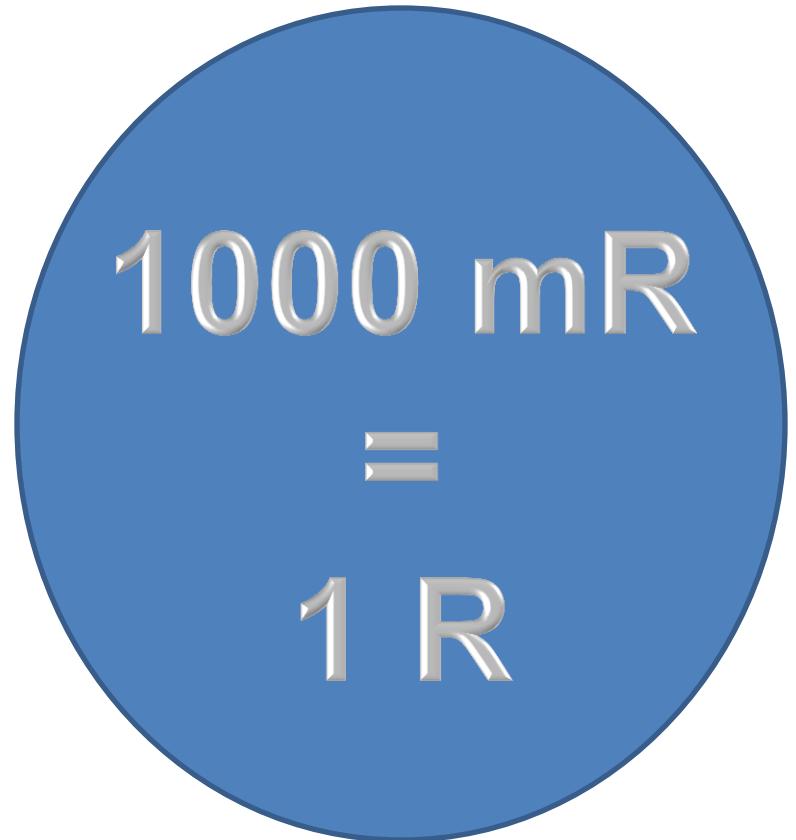


Academy Artworks

REM (Roentgen Equivalent in Man)

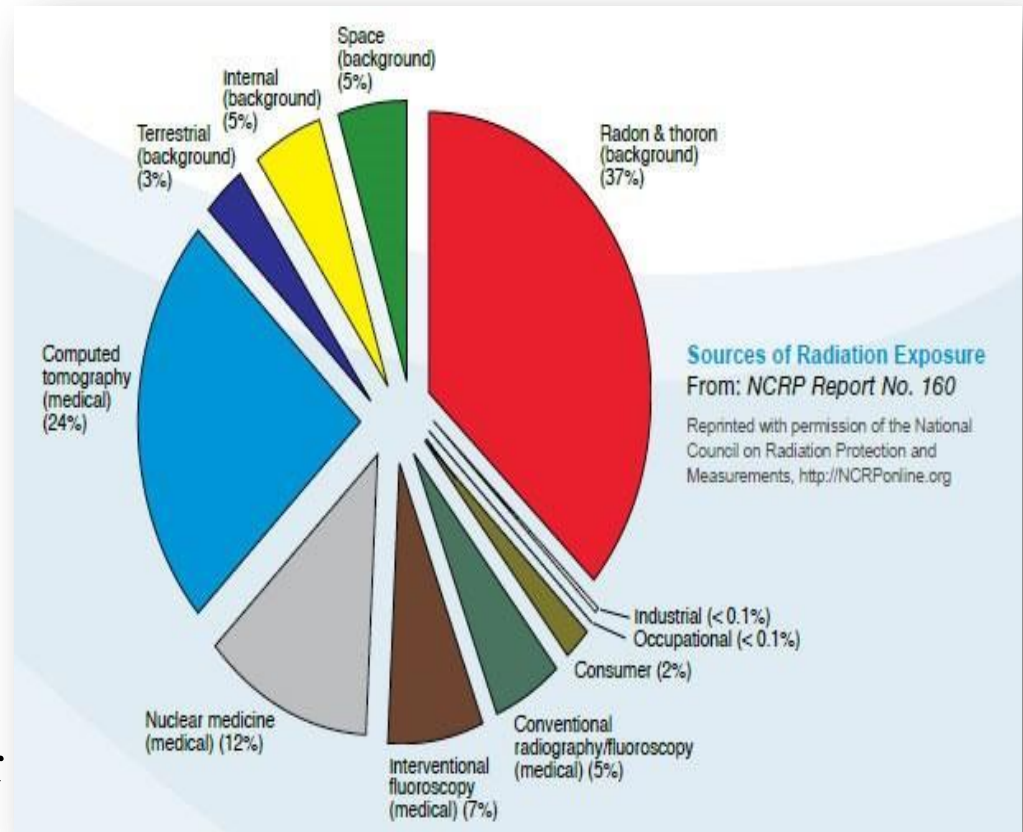
- A unit of radiation dose equivalent used to measure the amount of damage to human tissue caused by all types of ionizing radiation

$$1 \text{ R} = 1 \text{ Rad} = 1 \text{ Rem}$$


$$1000 \text{ mR} = 1 \text{ R}$$

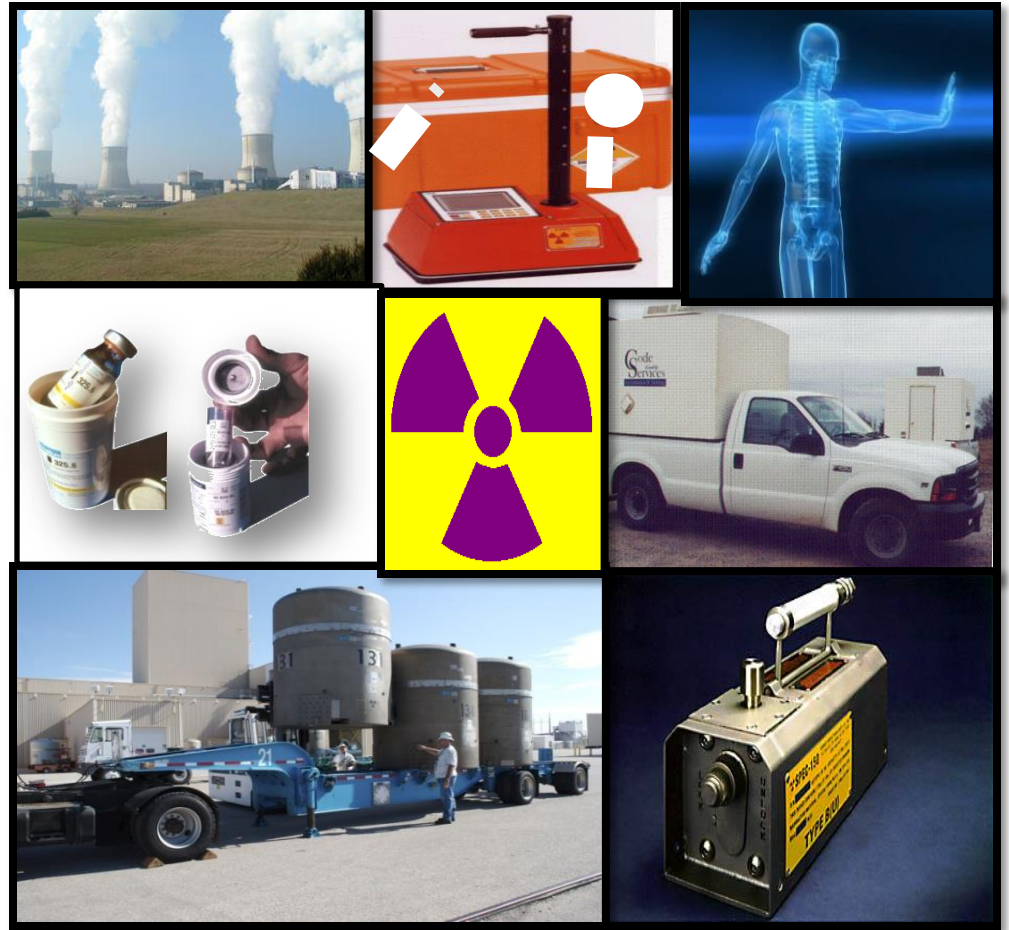
Average Annual Radiation Exposure

- 620 mR/yr
- ~310 mR from natural radiation
- ~310 mR from man-made radiation
- <1 mR from nuclear power generation



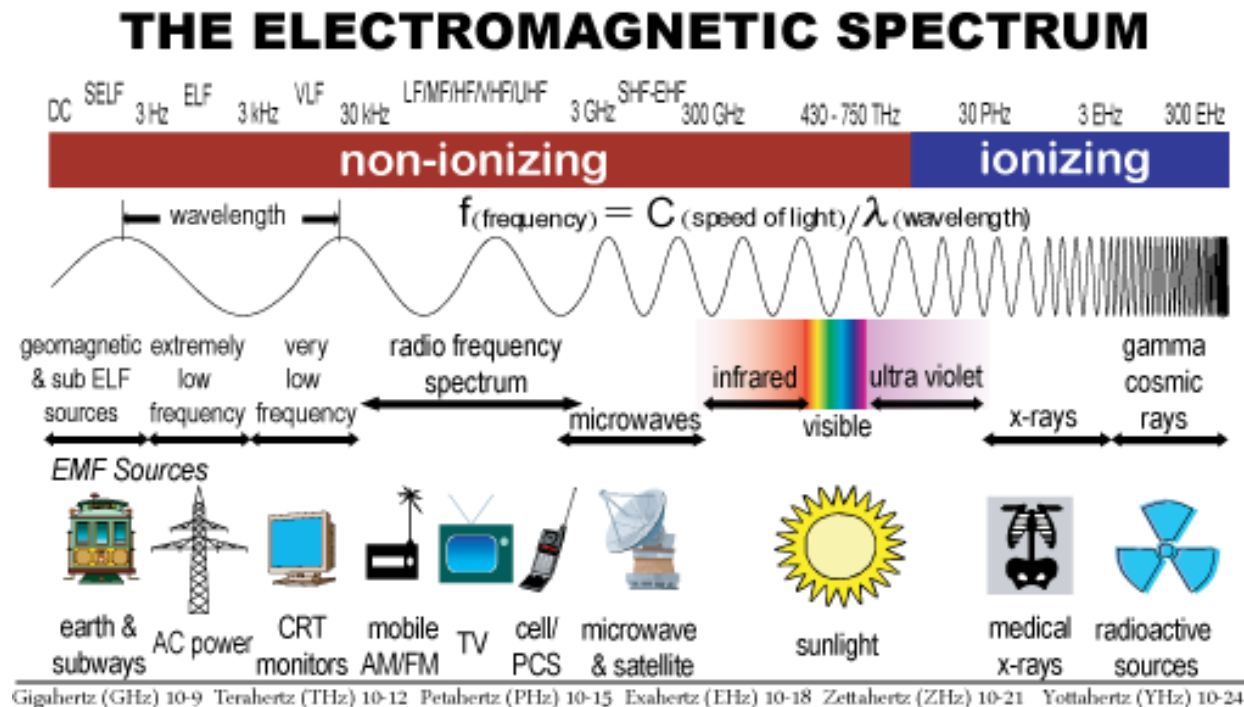
Radioactive Material in Alabama

- Nuclear Power Plants
- Medical Uses
- Industrial Uses
- Research
- Naturally Occurring Radioactive Material (NORM)
- Waste Isolation Pilot Project (WIPP)

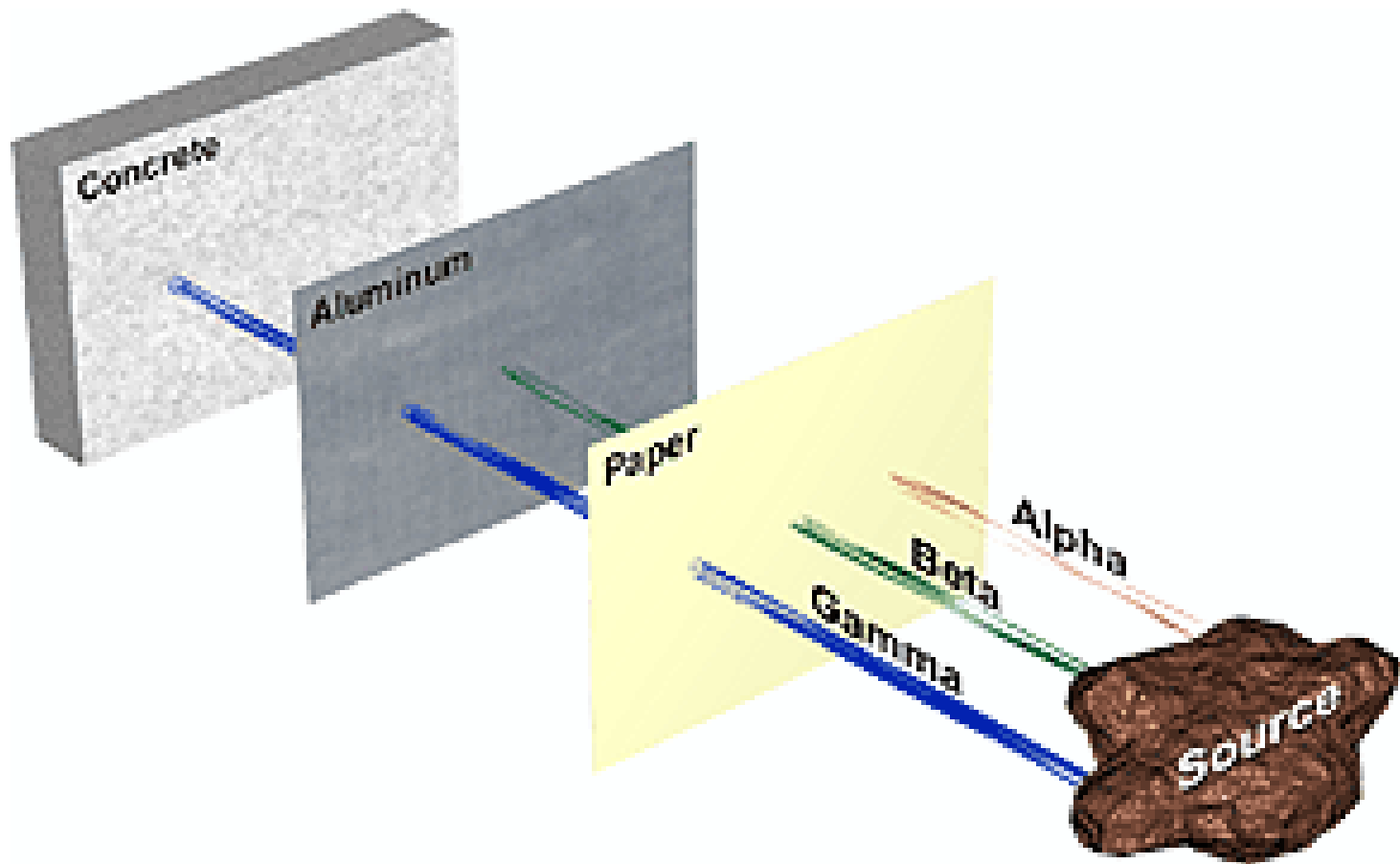


Two Types of Radiation

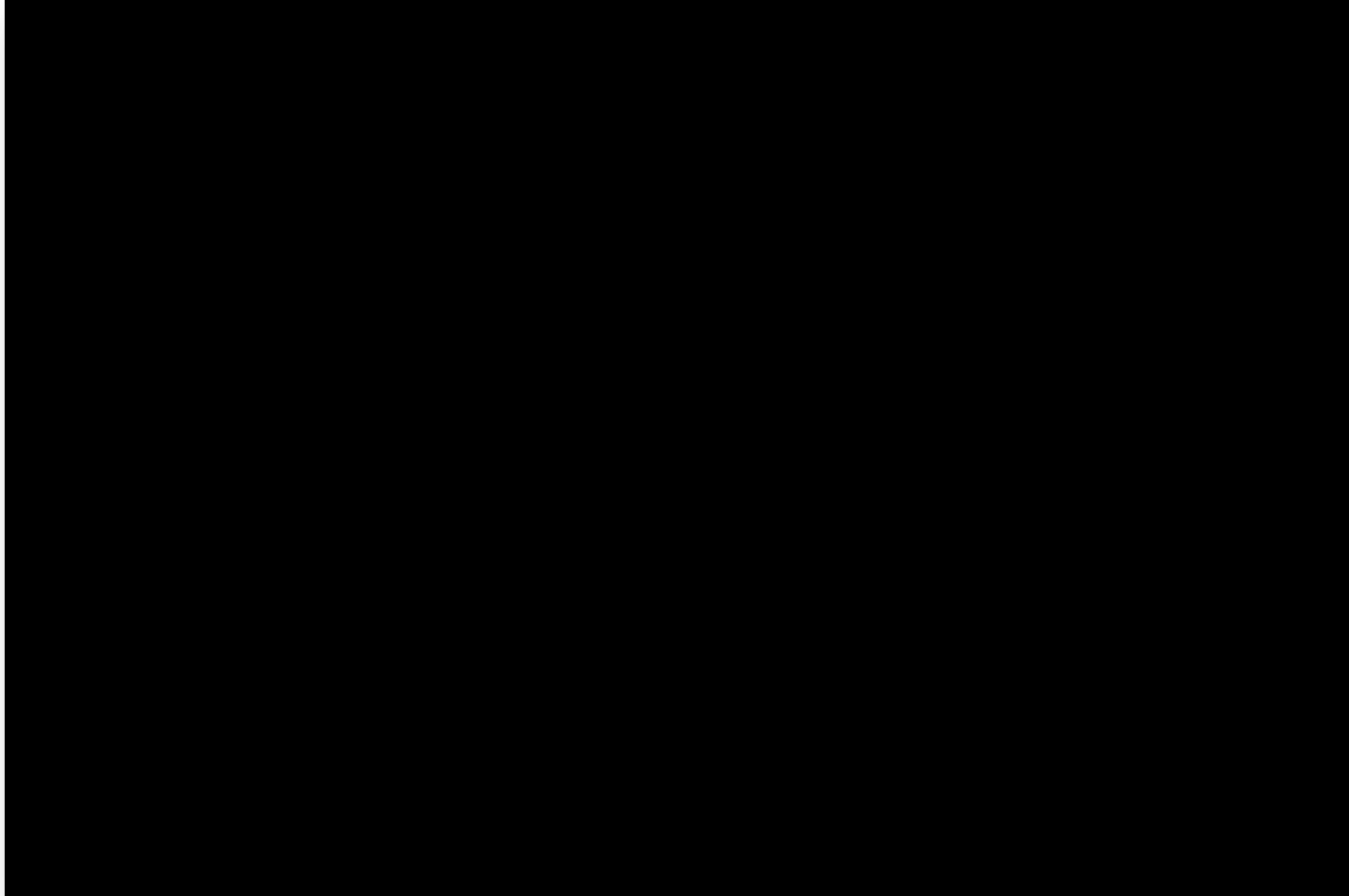
- NON-IONIZING: Radio and TV Waves, Infra-Red, Microwaves, Ultra-Violet
- IONIZING: Alpha Particles, Beta Particles, Gamma Rays, X-rays



Ionizing Radiation



Four Types of Ionizing Radiation



ALARA

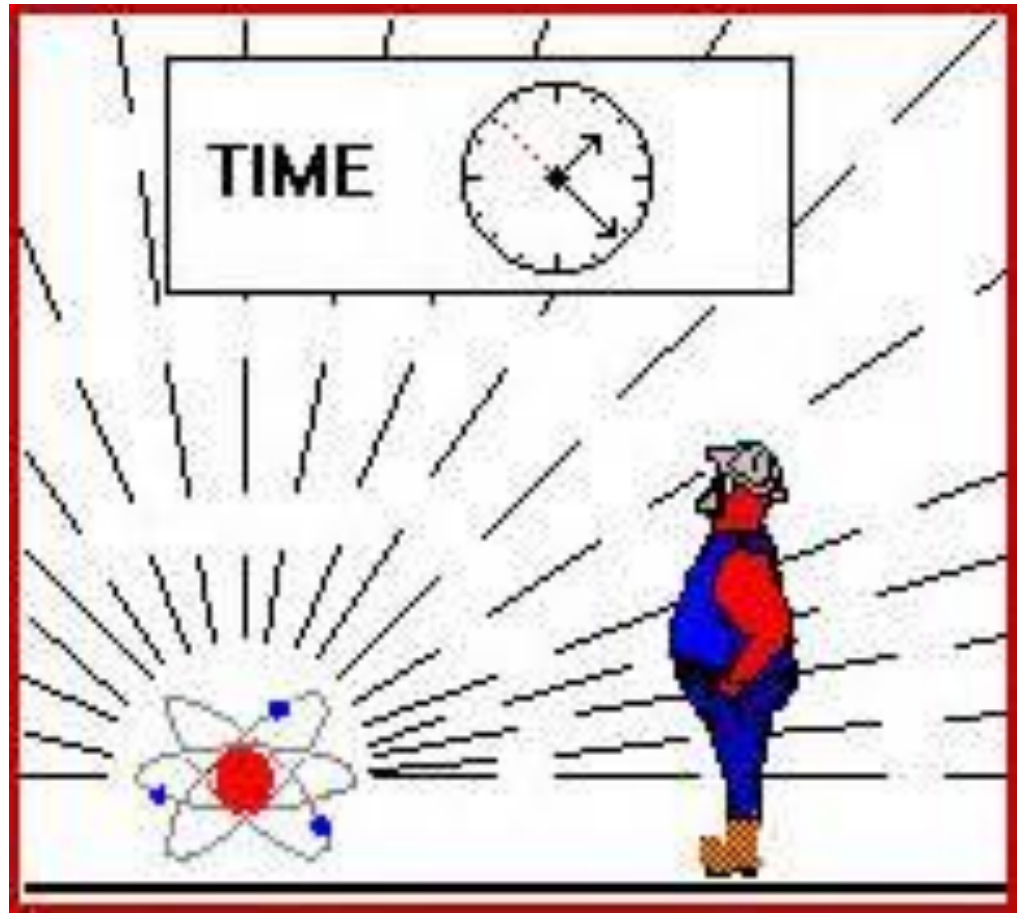


Controlling Exposure



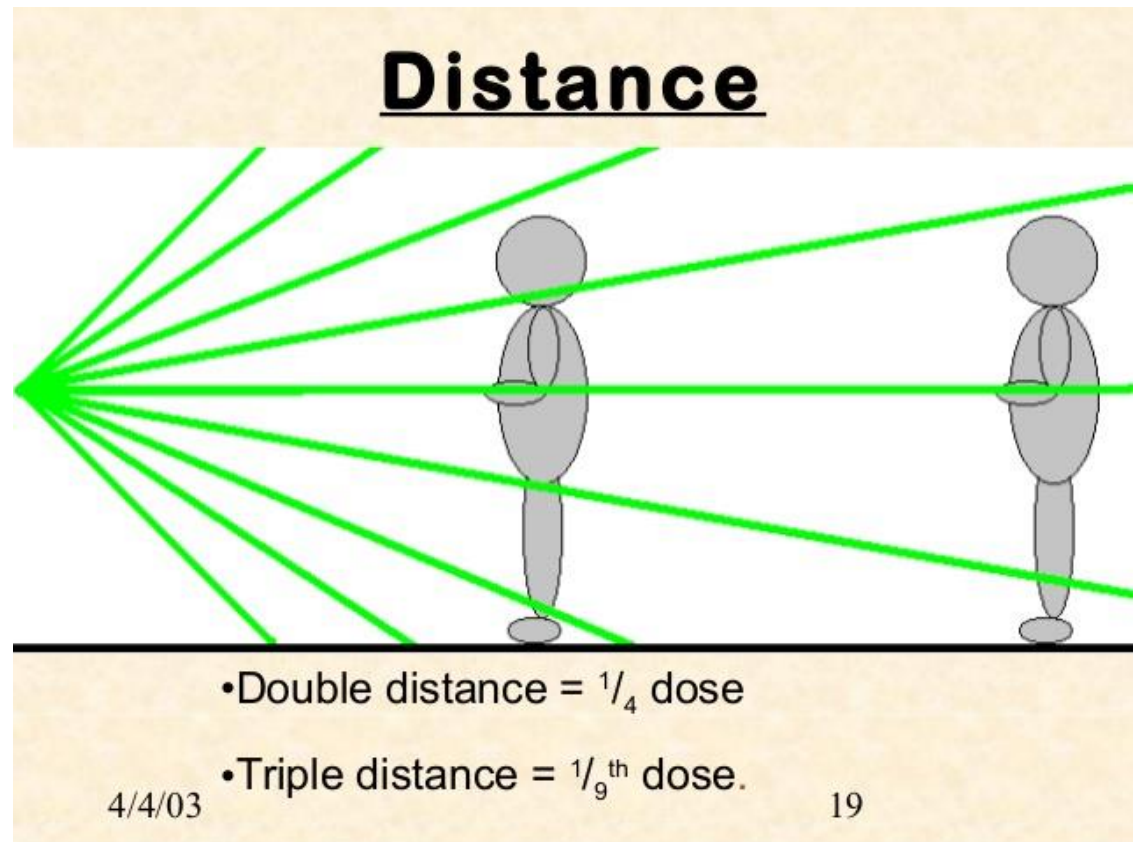
Protection from Radiation-Time

Less time in a
radiation area
=
Less radiation
exposure



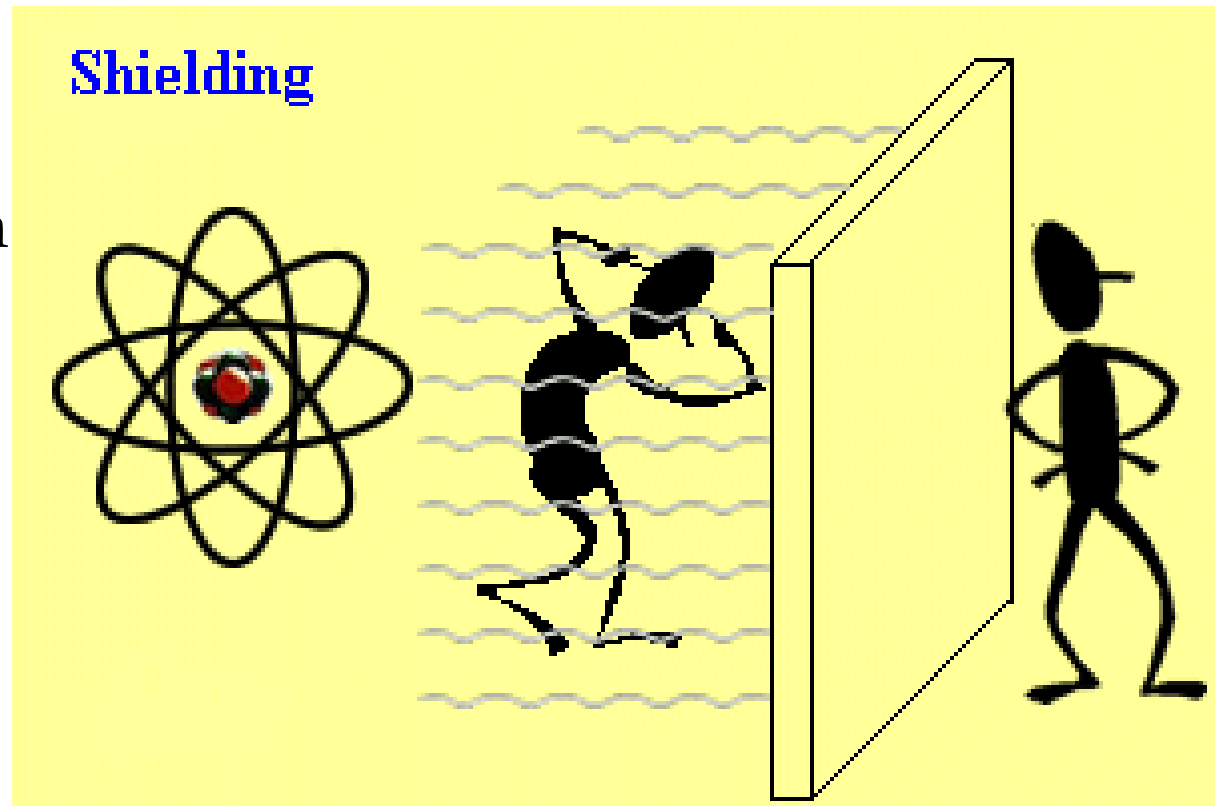
Protection from Radiation-Distance

Greater the distance to
ionizing radiation
=
Less radiation
exposure

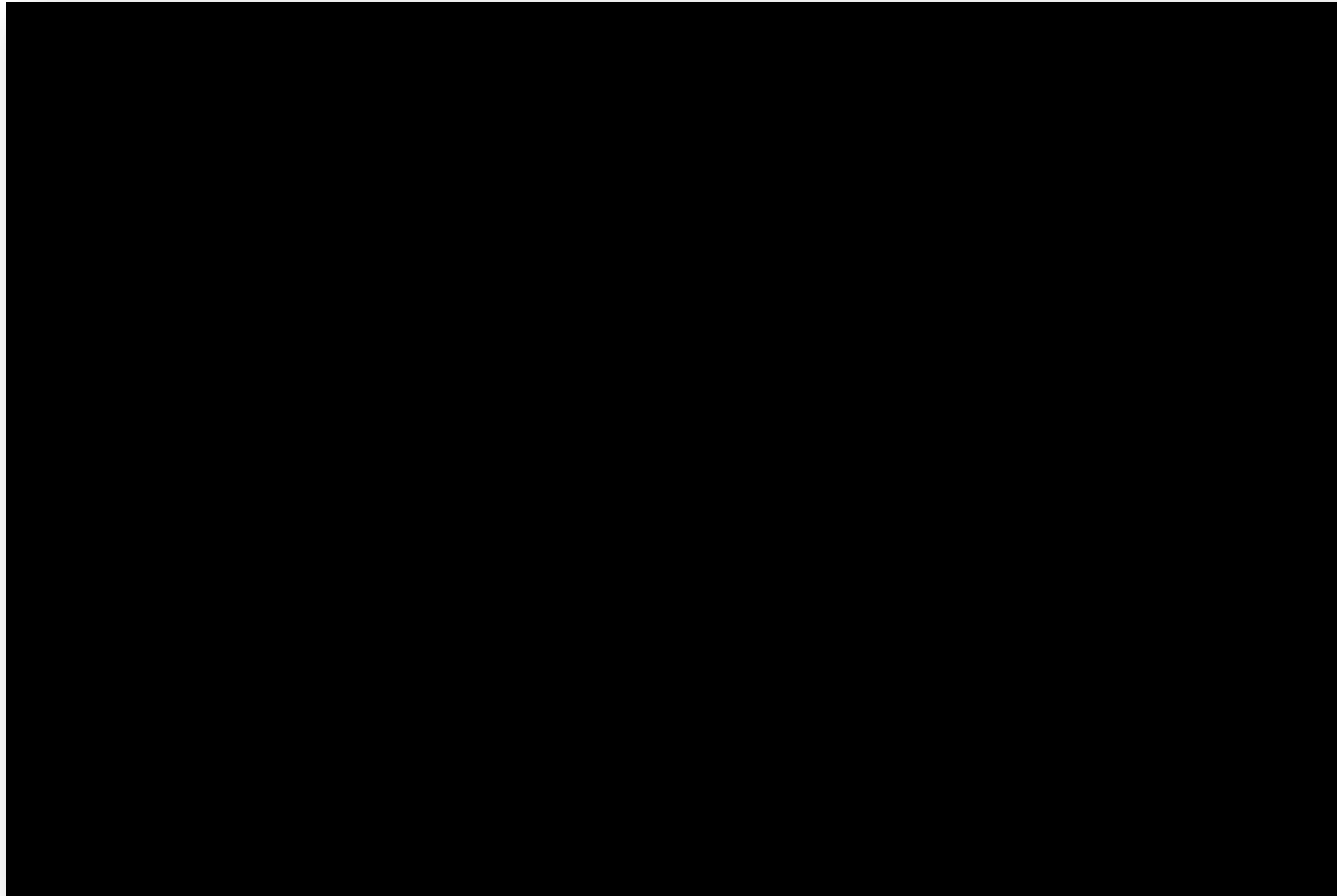


Protection from Radiation-Shielding

Thicker/Denser
Material
=
Less radiation
exposure

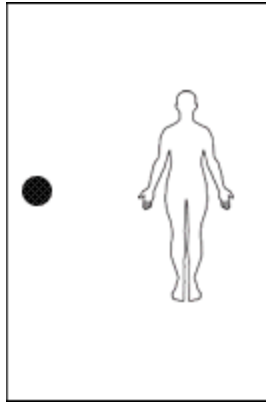


Time, Distance & Shielding

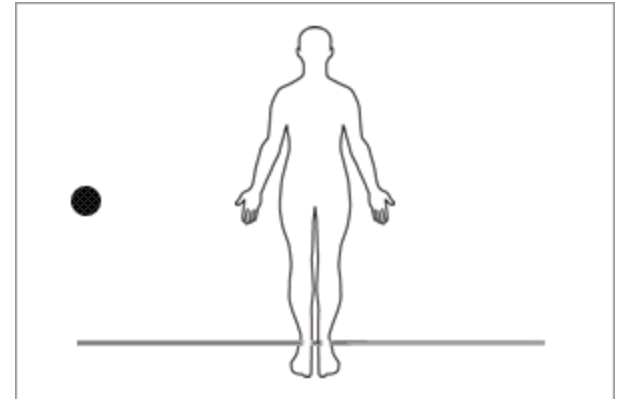


Exposure, Contamination & Decontamination

- **Exposure**



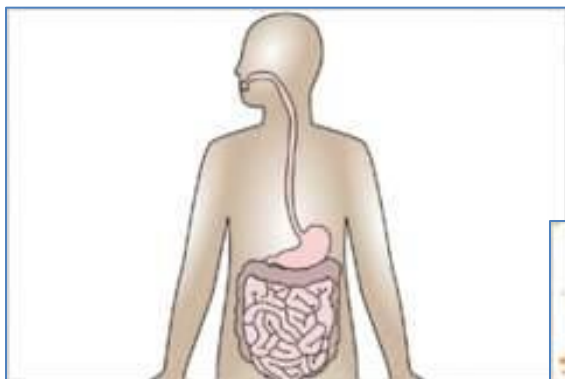
- **Contamination**



- **Decontamination**

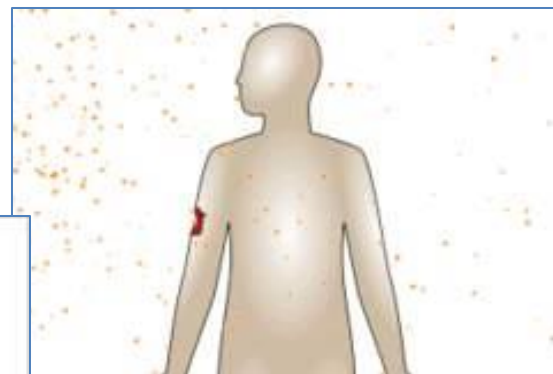
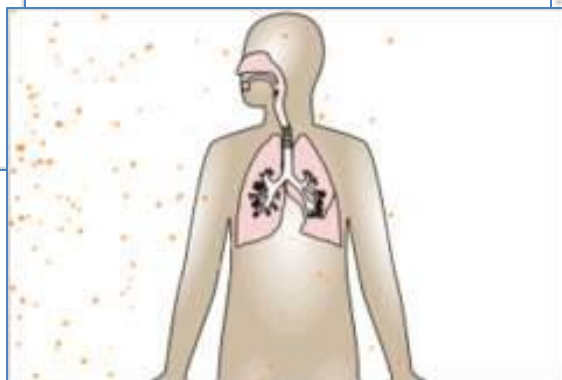


Radiation Pathways



Ingestion

Inhalation



Absorption

Avoid Radioactive Contamination

Do not:

- Eat
- Drink
- Smoke
- Chew
- ChapStick
- Make-Up

Use PPE while on the scene of an incident involving radioactive material

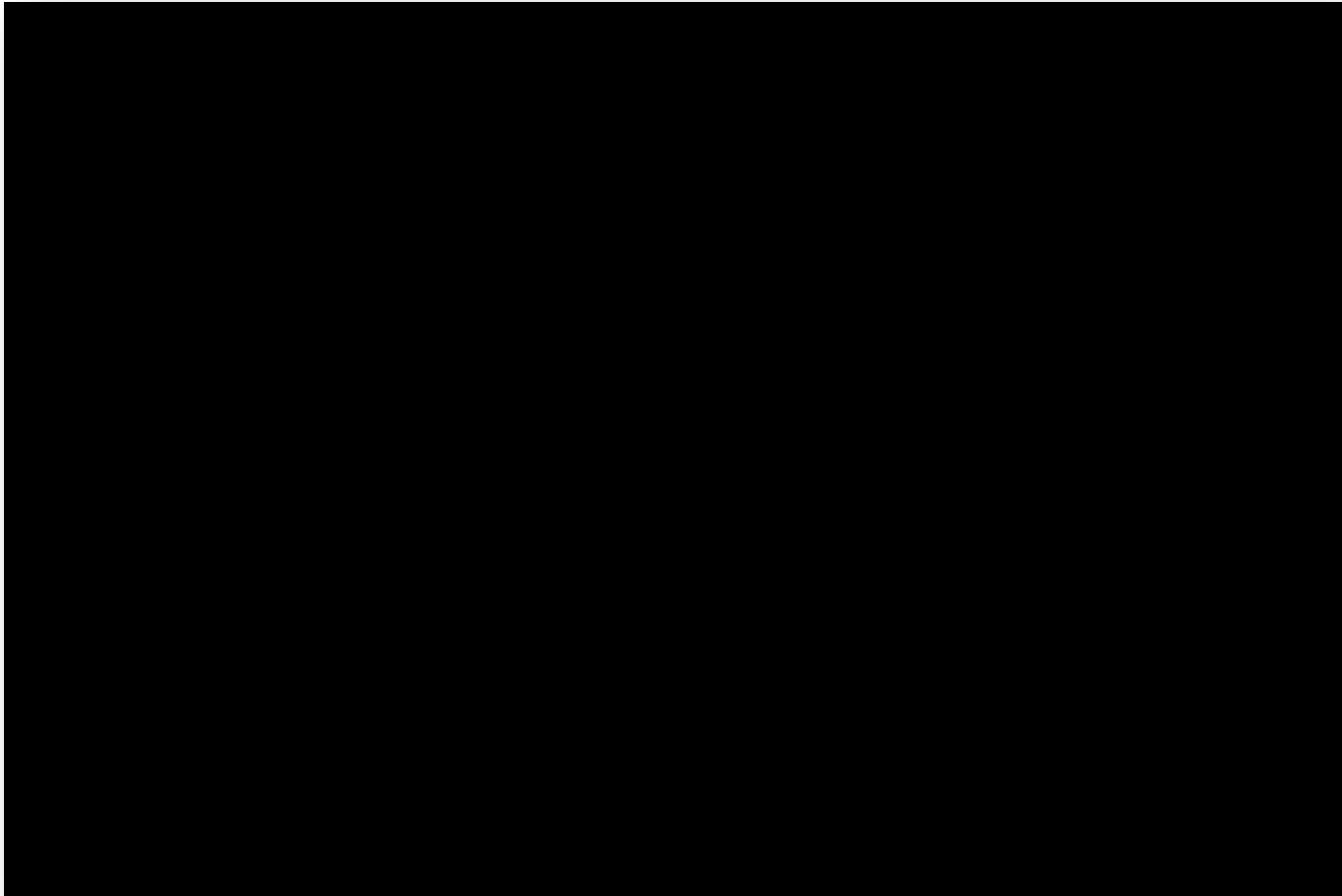


Contaminated Injured

In all cases,
the treatment of an
injury takes priority
over decontamination



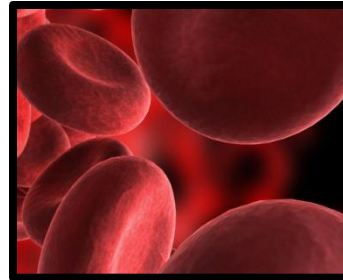
Radiological Basics



Biological Effects of Radiation

- Acute Effects

Nausea, Vomiting, Diarrhea,
Hair Loss, Infection, Death

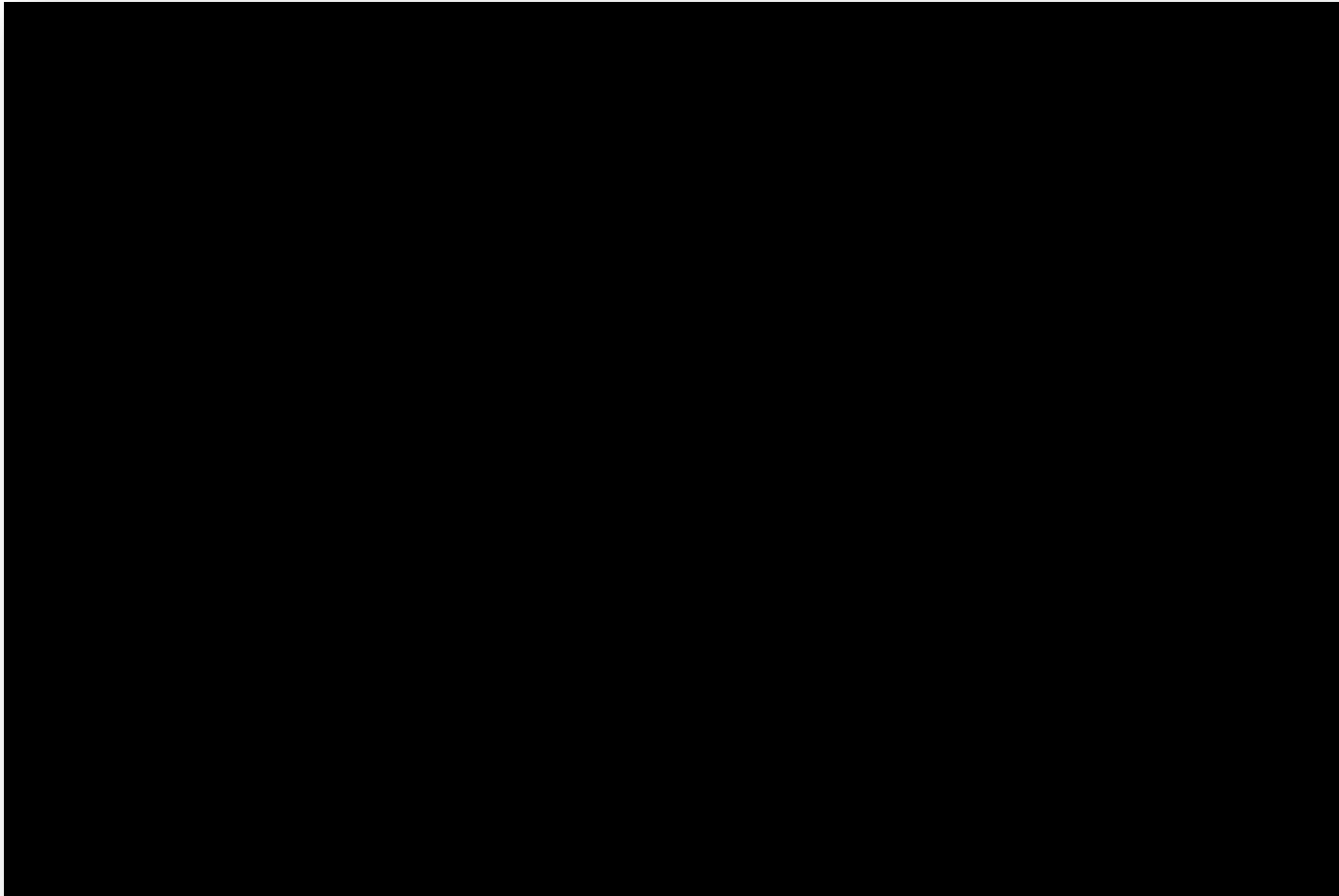


- Chronic Effects

Reduced Fertility, Cataracts,
Leukemia, Other Cancers,
Life Shortening, Genetics
effects



Biological Effects



Radiation & Our Five Senses

- We are aware of our environment through our five senses



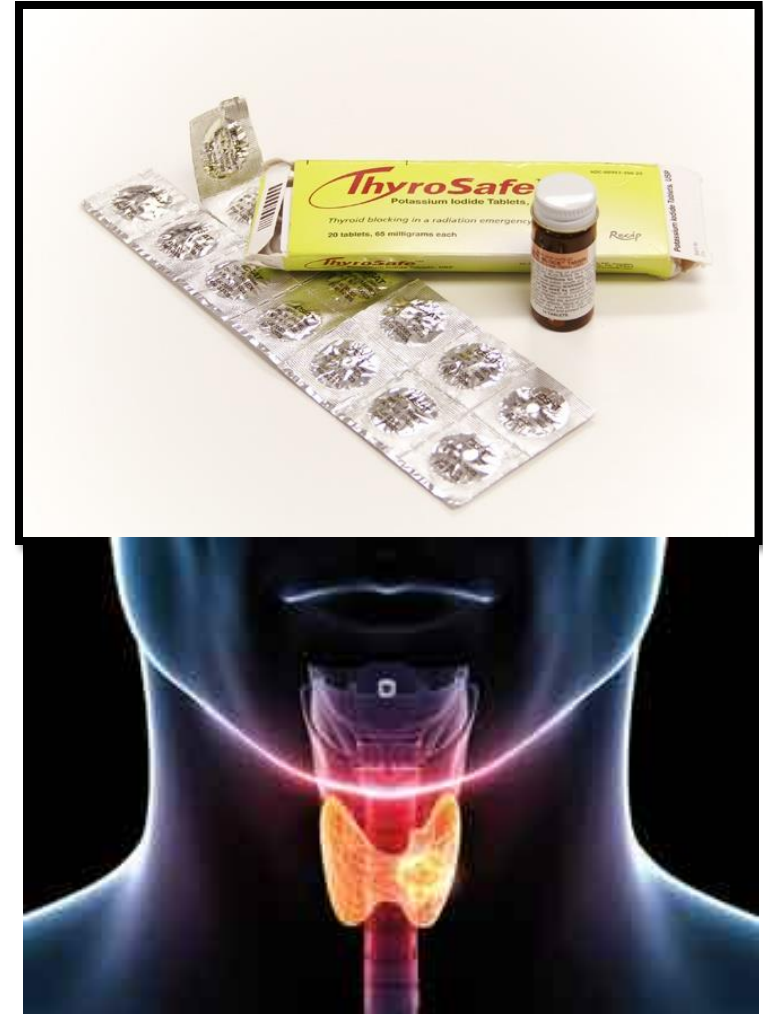
FIGURE 15.—Man being bombarded by "invisible" rays.

- You must rely on instruments to detect the presence of radiation



KI (Potassium Iodide)

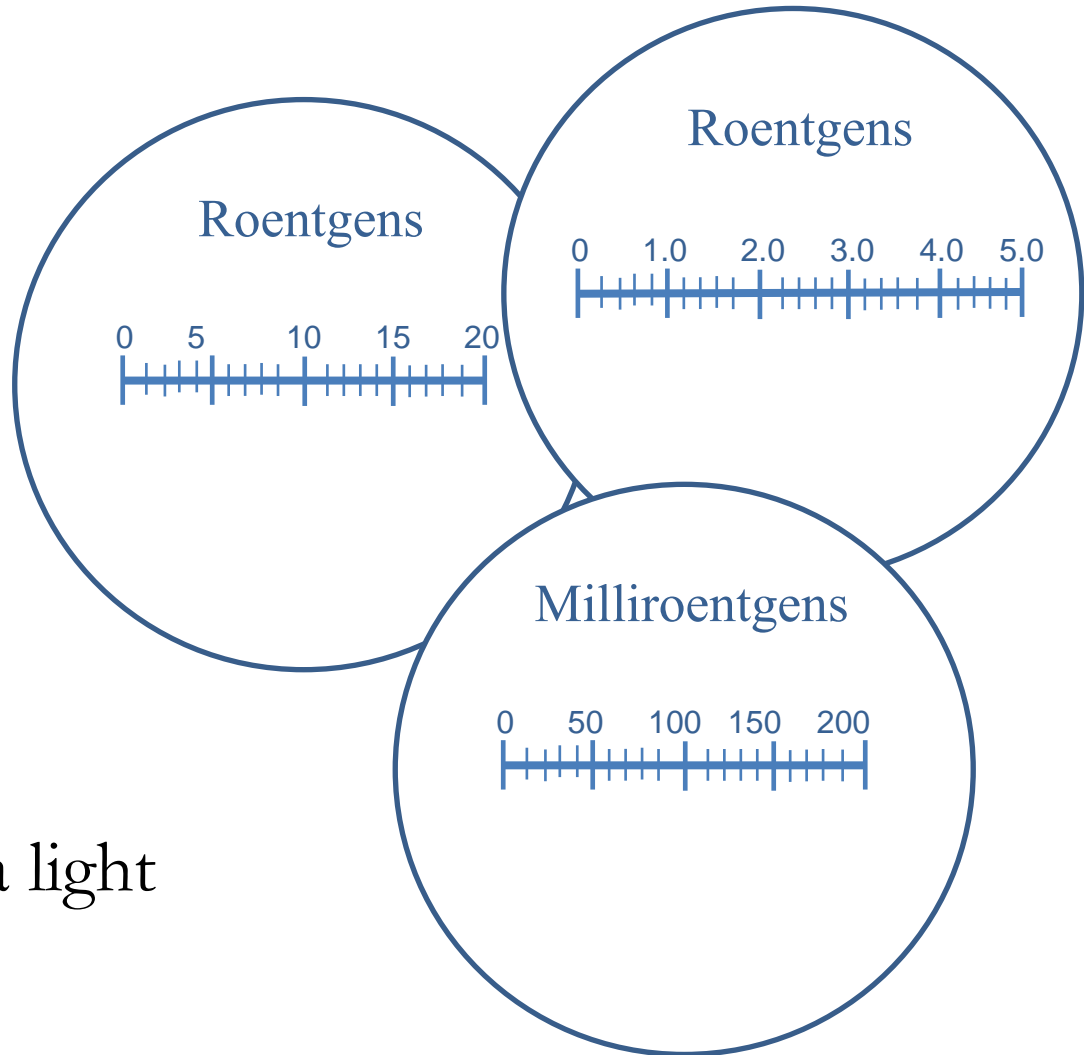
- Thyroid Blocking Agent
- Fills the thyroid gland with non-radioactive iodine
- Helps radioactive iodine from being absorbed into the thyroid
- Adult dosage 130 mg/day



Pocket Dosimeters



- Look through the dosimeter toward a light source

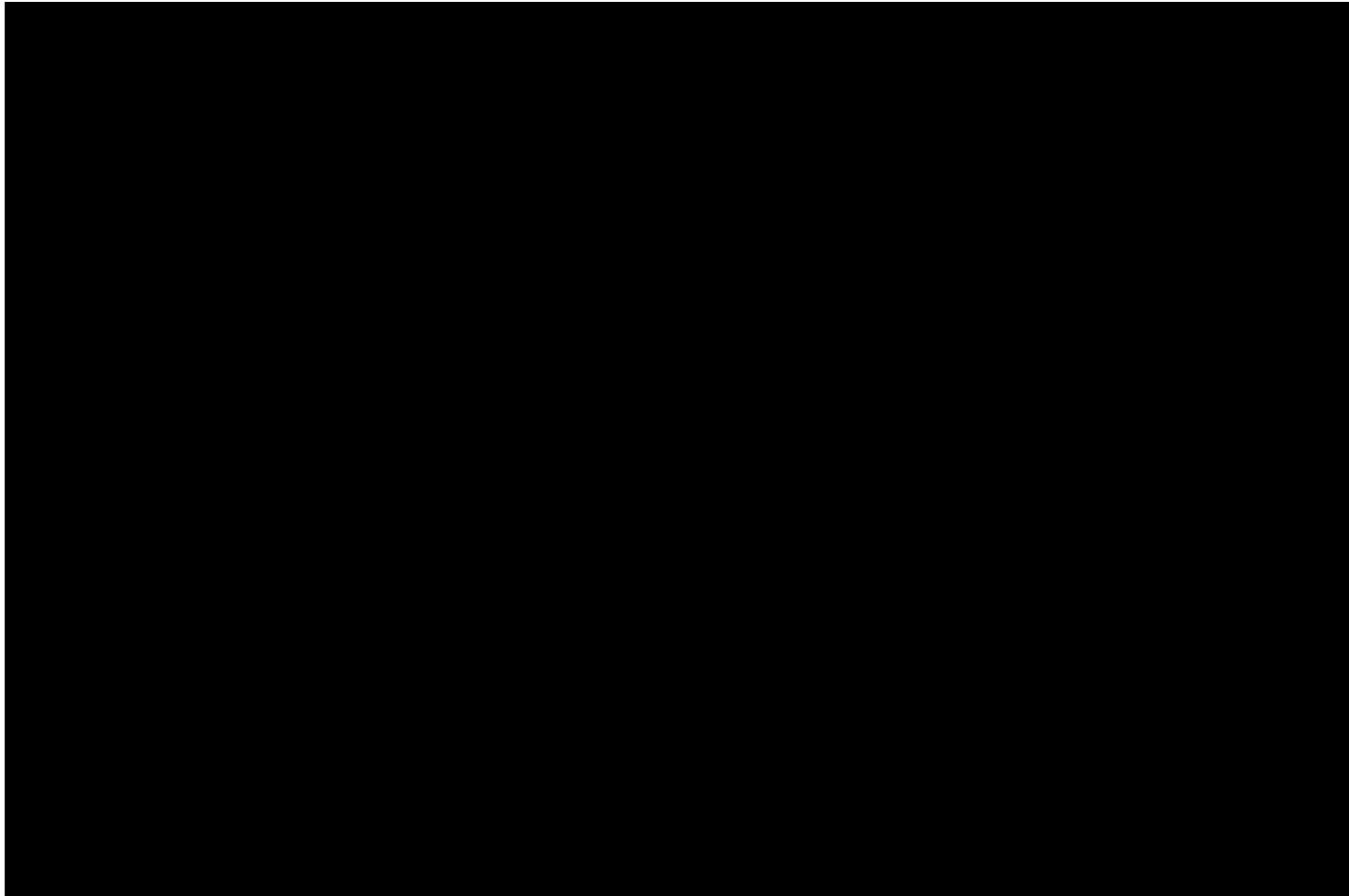


Radiation Exposure

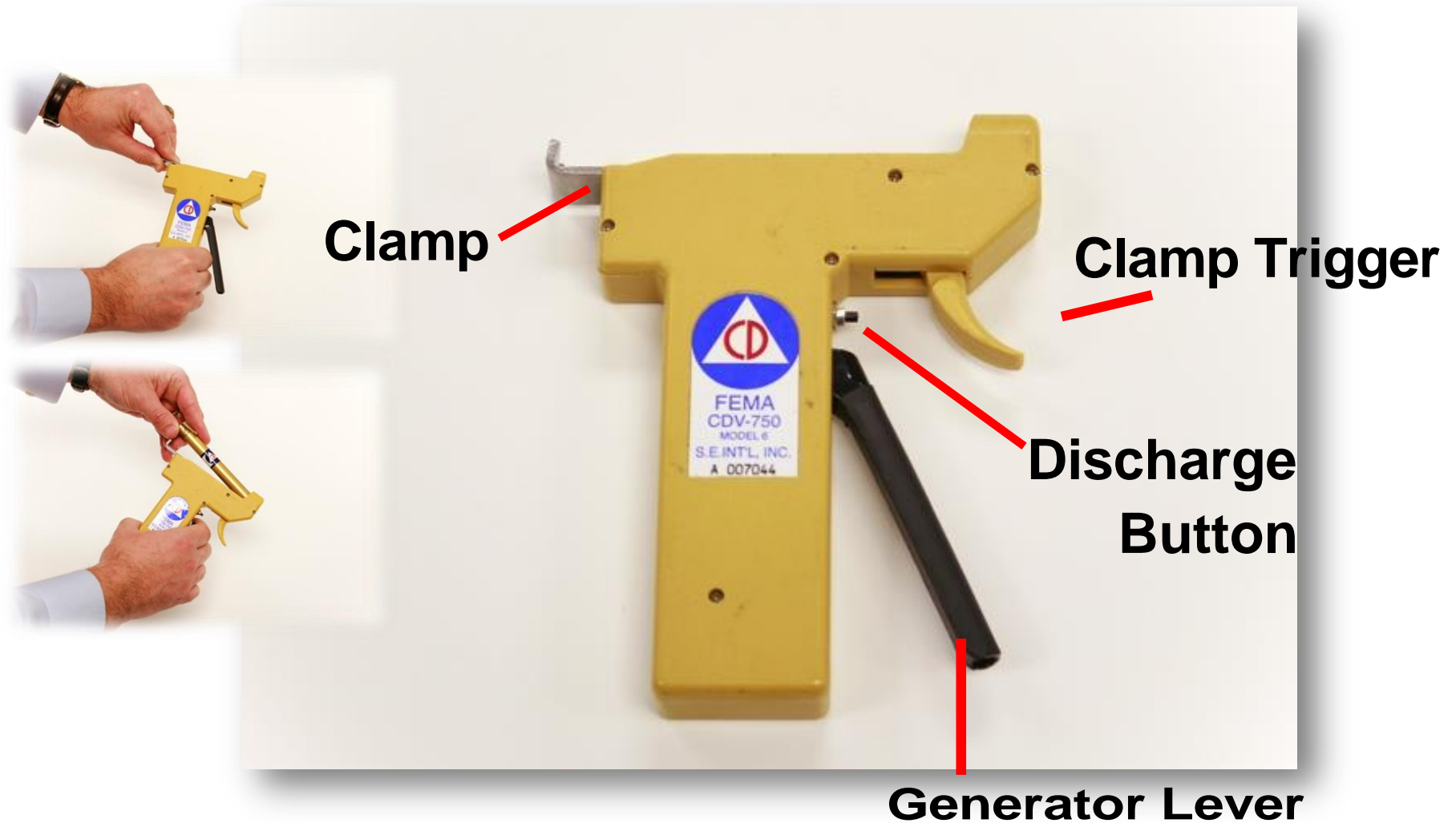
- Dosimeter = Odometer
- Accumulated Exposure



Radiological Dosimetry

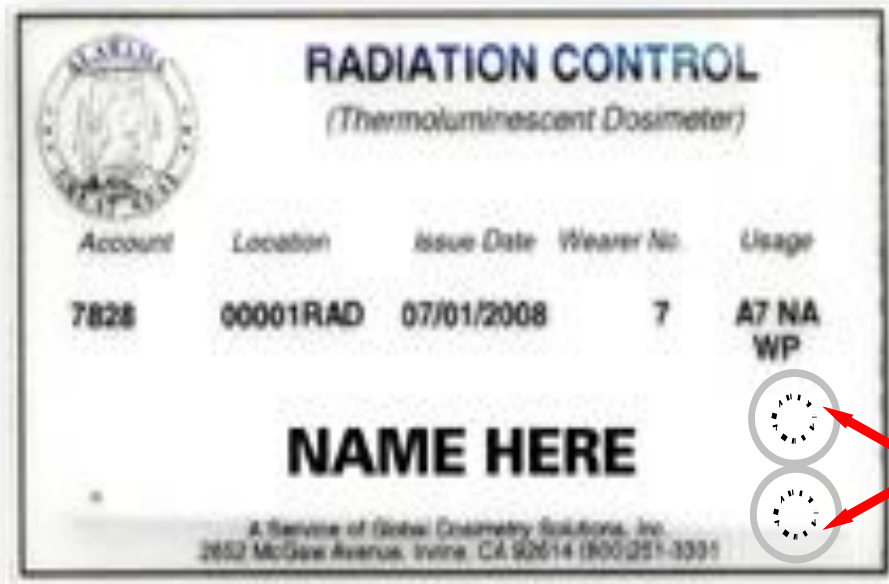


CDV 750 Dosimeter Charger



Thermoluminescent Dosimeter

- Records radiation dose for legal/permanent exposure records
- Results not immediately available



Lithium
Fluoride
Chips

Placement of the TLD & Pocket Dosimeter

TLD



Pencil/Pocket



TEDE

(Total Effective Dose Equivalent)



- Total Dose = External + Internal = 2 x External Dose
- TEDE = 2 x Pocket Dosimeter Reading

Radiation Dosage Limits for Emergency Workers

EMERGENCY WORKERS

Radiation Dosage Limits

TEDE (Total Effective Dose Equivalent)

Protecting Property, Patrolling Evacuated Areas, and Manning Check Points

	<u>TEDE</u>	<u>Dosimeter</u>
Seek Relief	200 mrem	100 mR
Daily Maximum	1 rem	500 mR
MAXIMUM for ACCIDENT	5 rem	2.5 R

In addition to the above individual limits, all emergency workers are advised to make a reasonable effort to limit their total dose, while at the same time accomplishing their emergency responsibilities.

Alabama Radiation Control

Additional Radiation Dosage Limits for Emergency Workers

Additional Radiation Dosage Limits for Emergency Workers

TEDE (Total Effective Dose Equivalent)

	<u>TEDE</u>	<u>Dosimeter</u>
Life Saving	25 rem	12.5 R
Evacuating Known Residents	10 rem	5 R
Fighting Residence Fires	10 rem	5 R

- Read dosimeters and record every 15-30 minutes.**
- Seek Relief at a reading of 100 mR on your dosimeter.**
- Contamination level in Alabama is twice (2x) background.**
- Do not take Potassium Iodide (KI) until instructed by your county EMA.**
- Control your exposure to radiation by your time, distance and shielding.**

Alabama Radiation Control

Emergency Worker Equipment



Radiation Exposure Record

Name:			SS# (last 4):			
Agency:			DOS#: 200 mR		() SR () 20R	
Date: (M/D/Y)			TLD#:			
Note! Read dosimeter every 30 minutes						
#	Time (24 hr)	Reading		Status (✓)		
		Low Range	High Range	Start	End	Total
1	Initial Reading					
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						



Emergency Worker Training

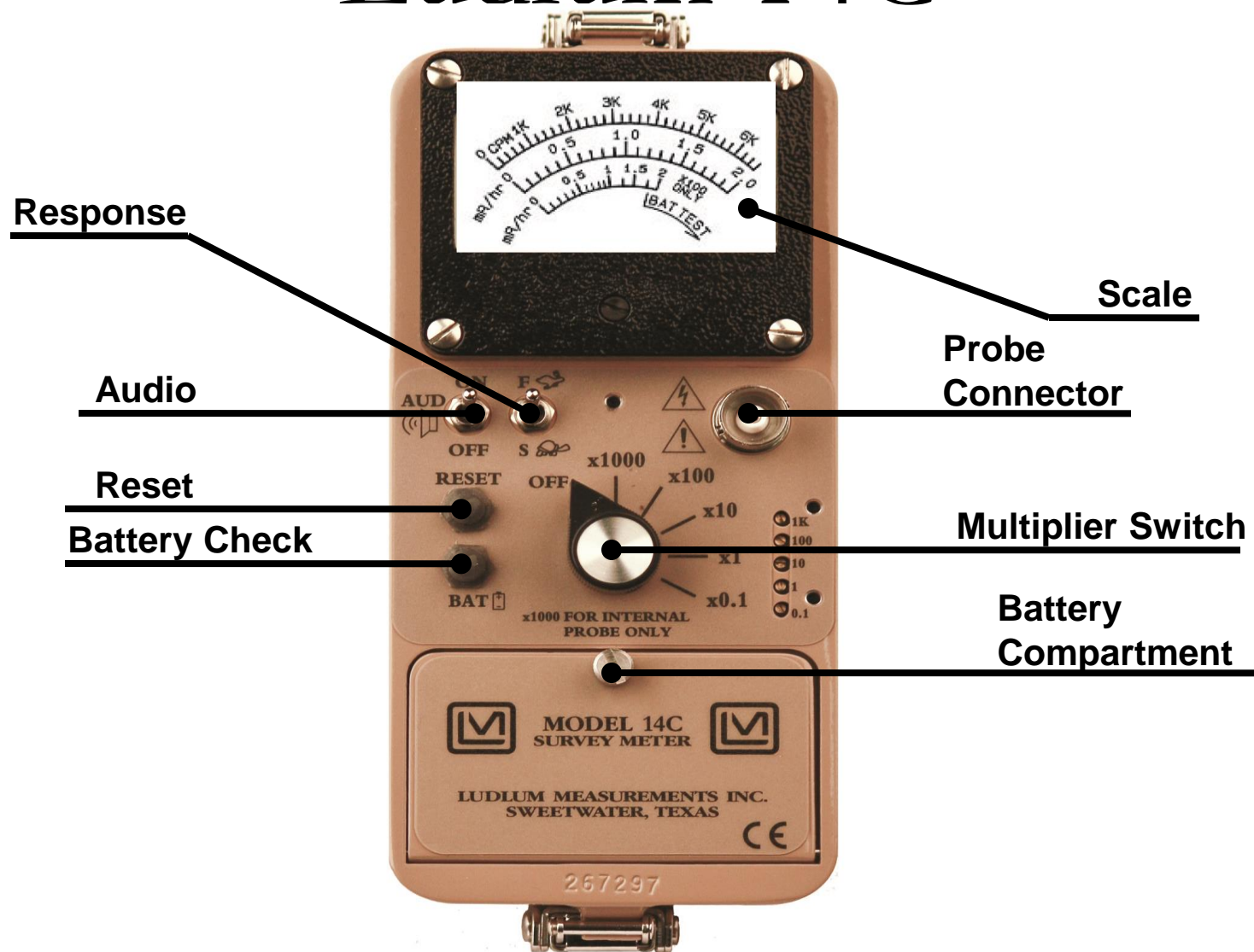


Radiological Survey Meter(s)

Ludlum 14C



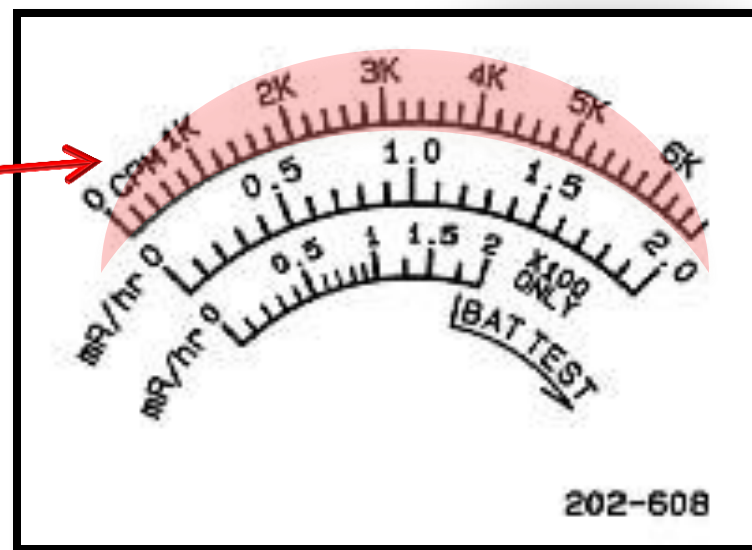
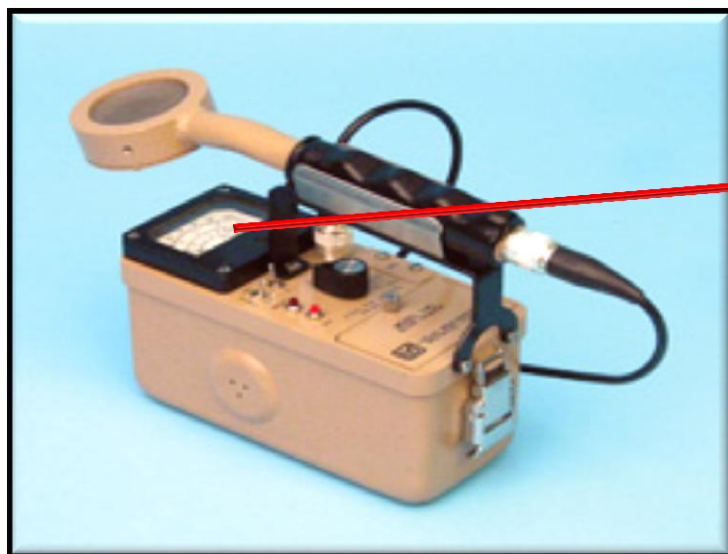
Ludlum 14C



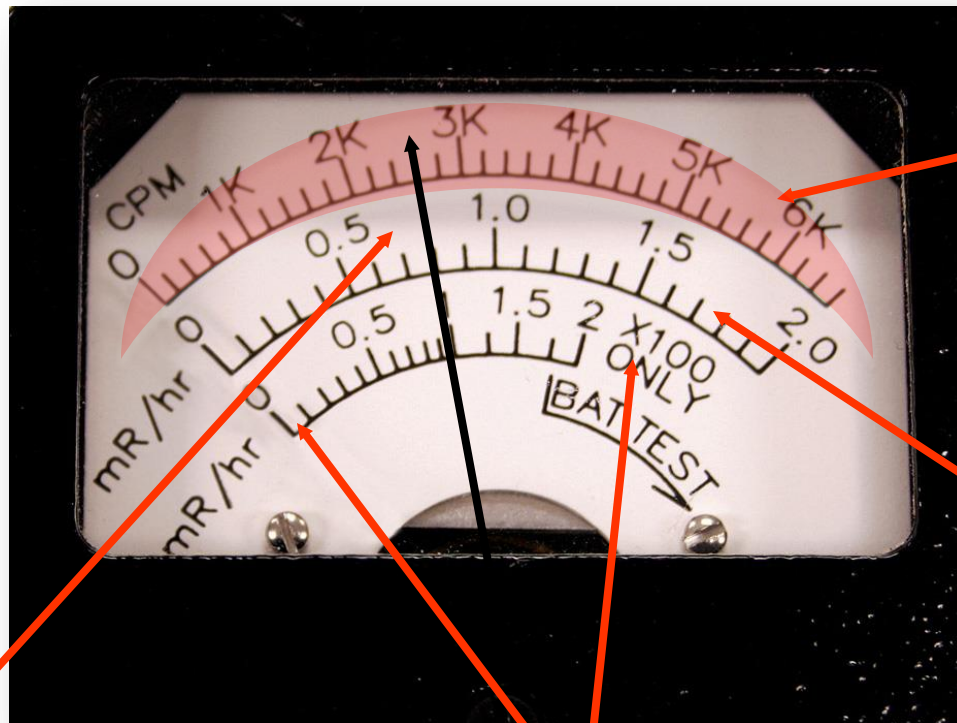
Radiation Contamination

Survey Meter = Speedometer

Only Use Top Scale: Counts per minute CPM or C/M



Ludlum 14C Scale(s)



**0-6,600 CPM
Pancake Probe**

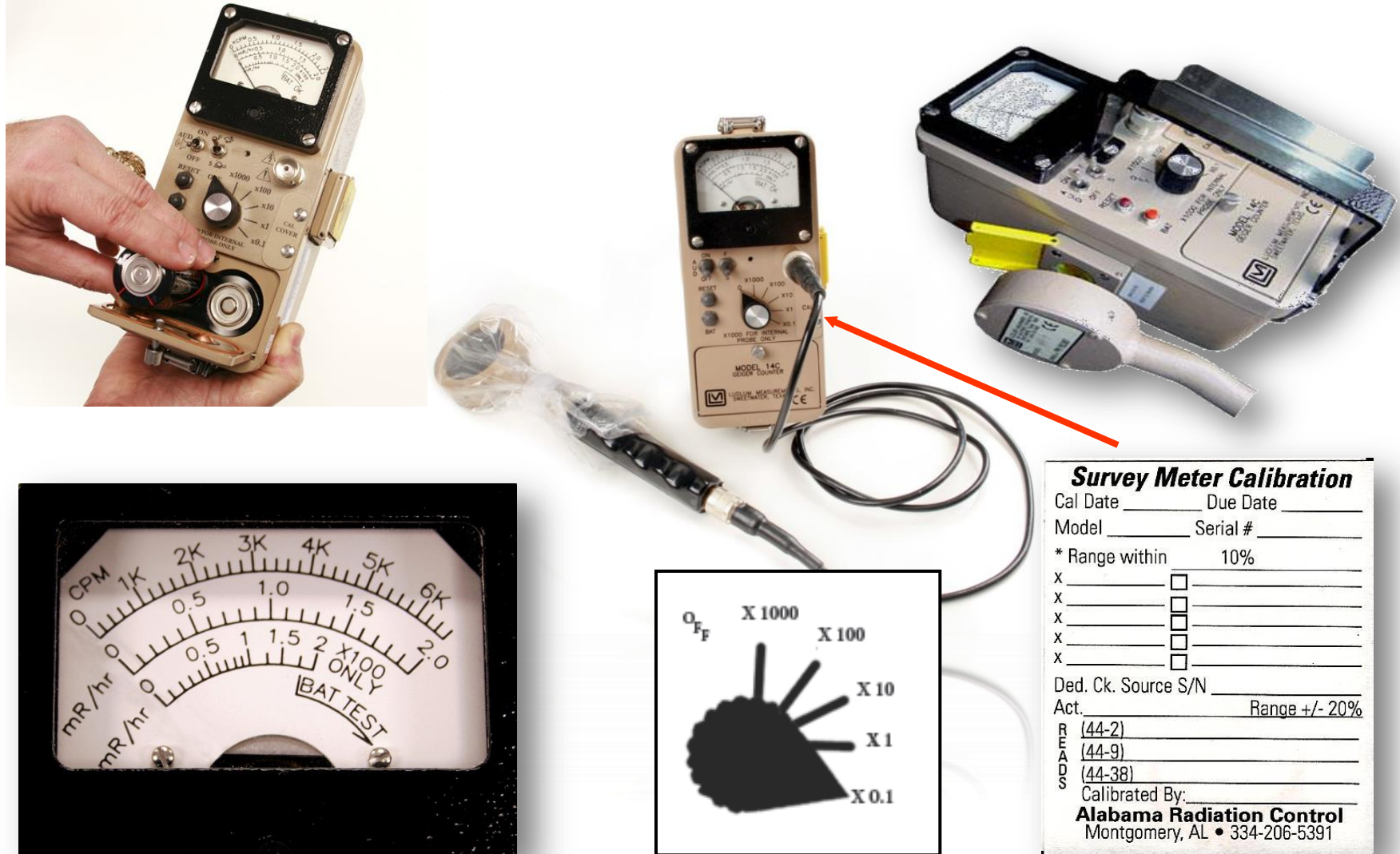


**0-2.0 mR/hr
HP Probe**

Hairline

**0-2.0 mR/hr
Use on X100 only
HP Probe**

Ludlum 14C-Set Up & Operation

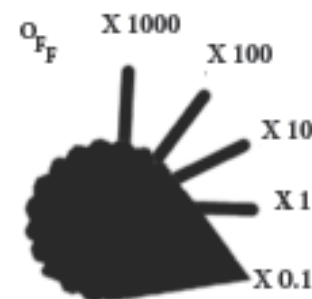


Ludlum 14C

What is the Meter Reading?

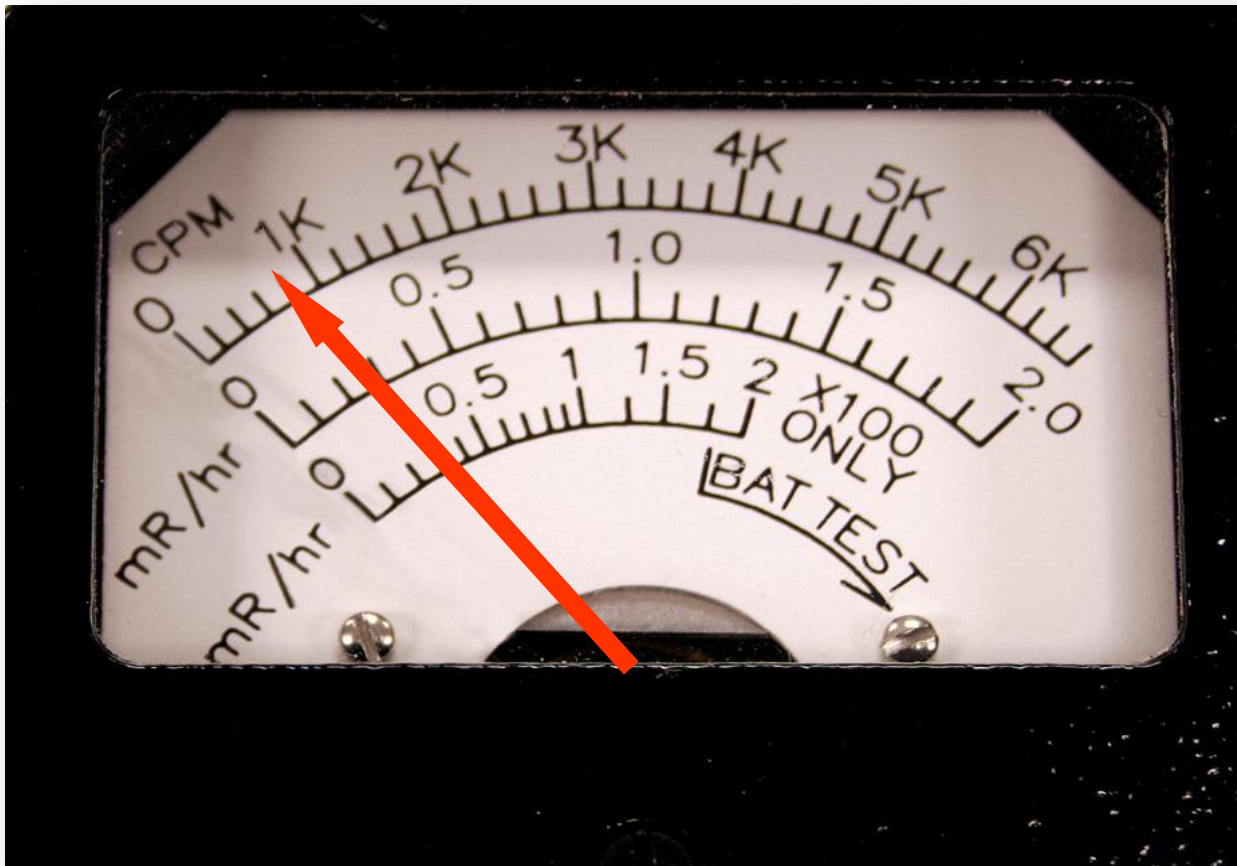


**360
CPM**

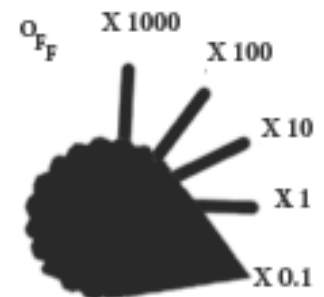


Ludlum 14C

What is the Meter Reading?

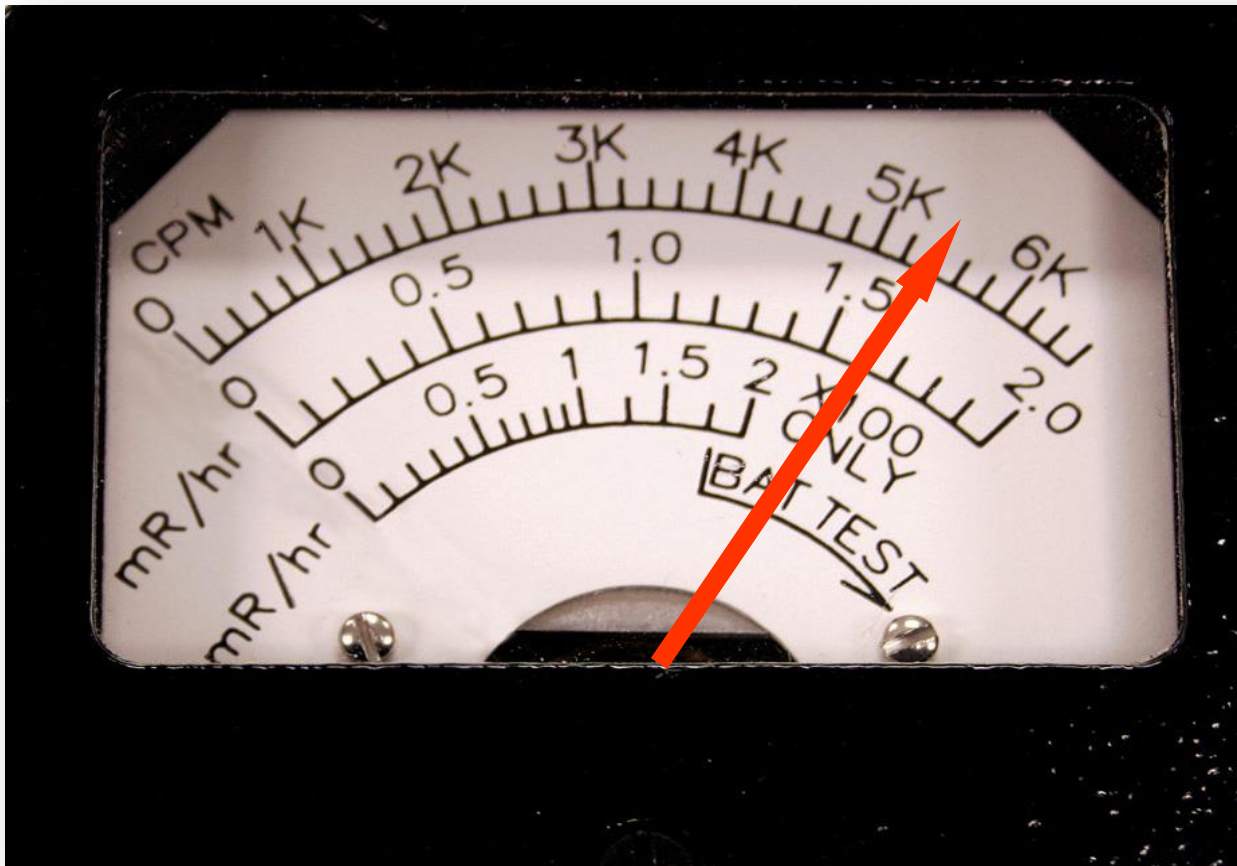


80
CPM

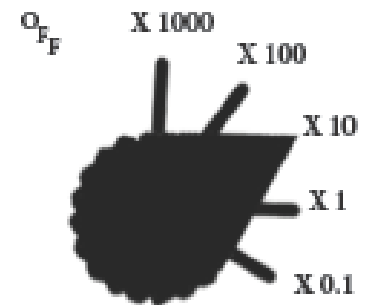


Ludlum 14C

What is the Meter Reading?

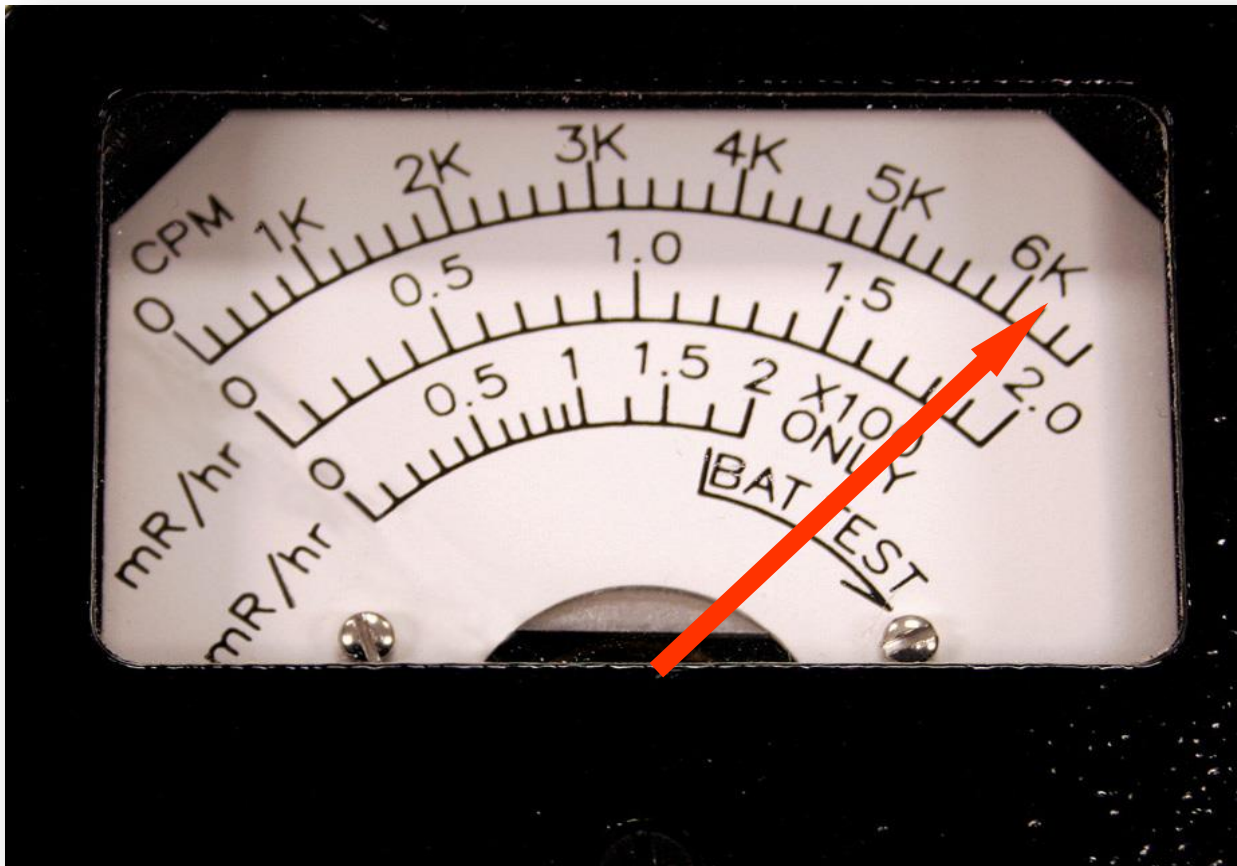


54,000
CPM

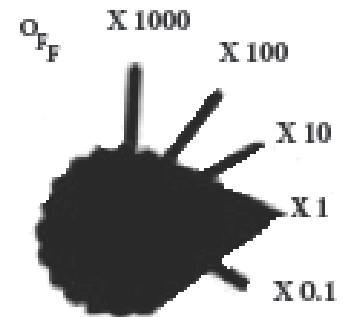


Ludlum 14C

What is the Meter Reading?



6,200
CPM

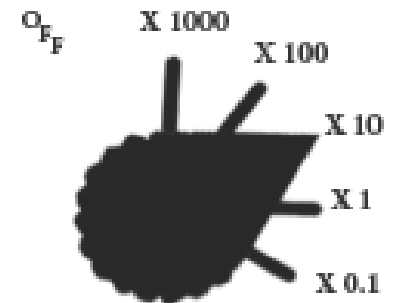


Ludlum 14C

What is the Meter Reading?



OFF-SCALE:
Need to change
“Multiplier
Switch” to x1.
Check cable
and batteries
“RESET”
button.

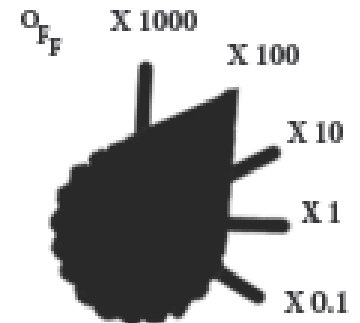


Ludlum 14C

What is the Meter Reading?



180,000
CPM



Ludlum 14C

What is the Meter Reading?



42,000
CPM

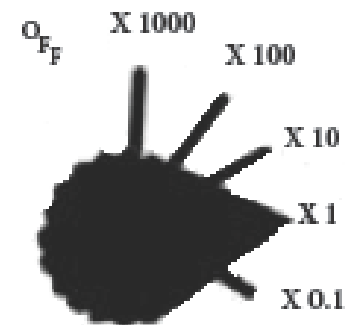


Ludlum 14C

What is the Meter Reading?



**2,400
CPM**

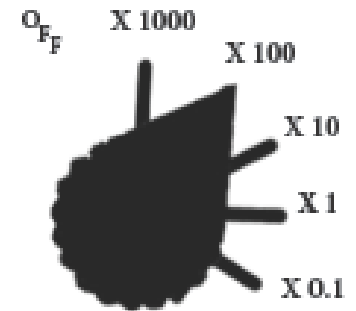


Ludlum 14C

What is the Meter Reading?

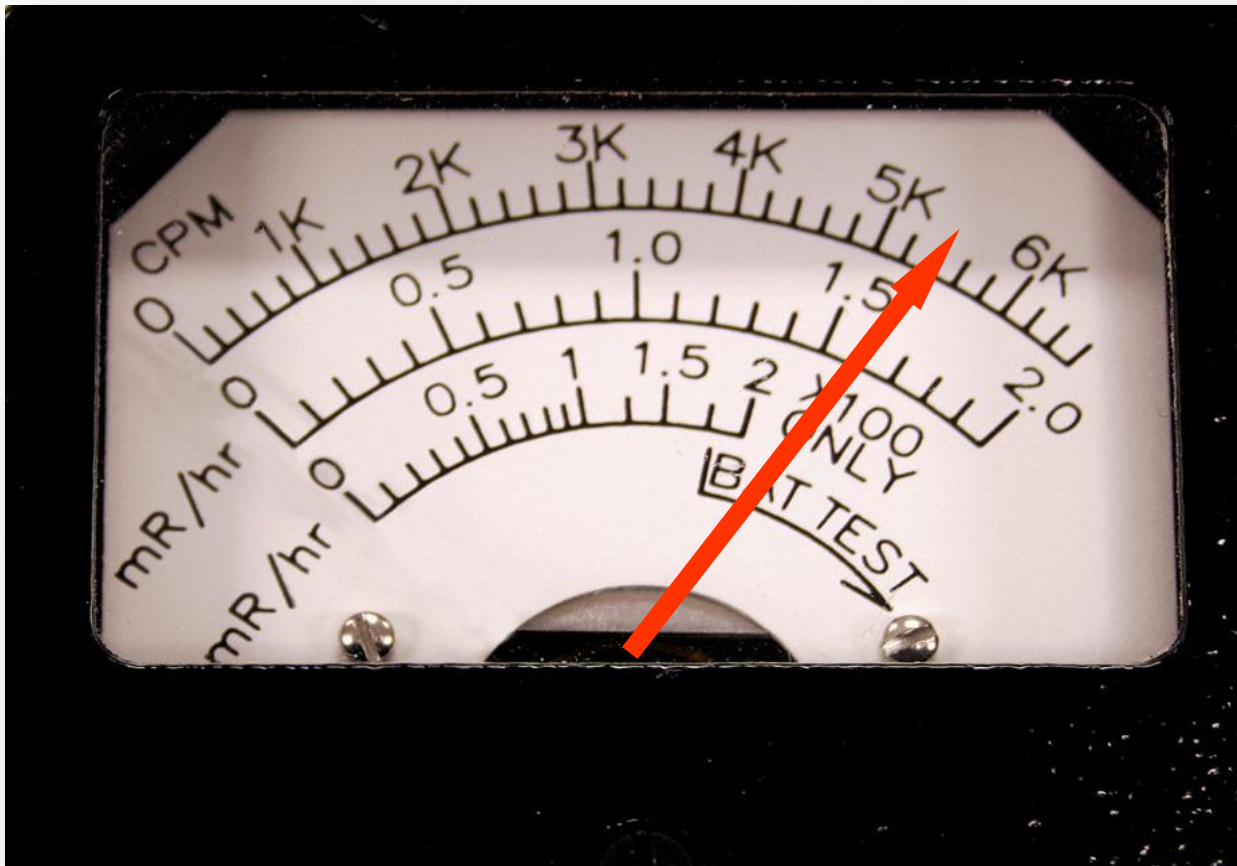


400,000
CPM

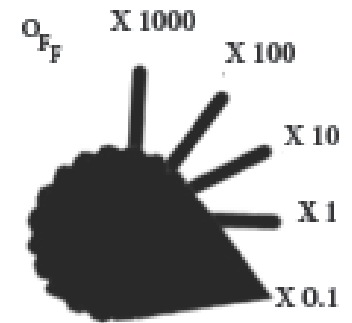


Ludlum 14C

What is the Meter Reading?



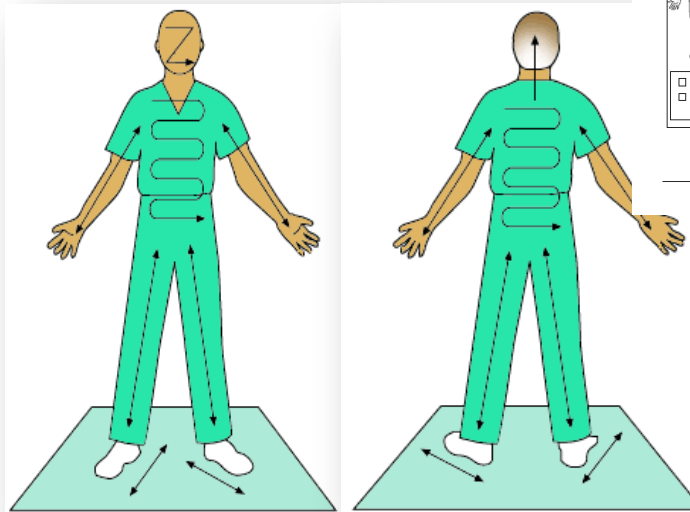
540
CPM



Ludlum 14C

Monitoring for Contamination

- Probe open window
- Hold probe 1 inch away
- Start at the head
- Move probe 1 inch per second
- Remember soles of feet
- Survey thyroid gland (probe closed window)
- Contamination
 - Twice background
 - 2 X background



Personnel Monitoring/Decontamination Record

PERSONNEL MONITORING/DECONTAMINATION RECORD			
PERSONAL INFORMATION			
Name:			SSN:
Address:			Sex: M/F
City:	State:	Zip Code:	Phone#:
Reception Center:			Date:
THYROID DOSE			
Ludlum 14C (multiply CPM x .04)		Adult Thyroid Uptake Limit - 5,000 mRem (5 Rem)	
CDV 700 (multiply CPM x .05)		NOTE: If reading ≥ 5 rem, escort individual to hospital for internal decontamination.	
Initial Reading:	mRem	Following 1 st Decon:	mRem
		Following 2 nd Decon:	mRem
EXTERNAL CONTAMINATION			
Note: Contamination Limit in Alabama is 2 x Background			
Area of Contamination (Indicate Location on Diagram Below)	Initial Reading (Hairline x Dial)	Background Reading: CPM	
	Reading Following 1 st Decon	Reading Following 2 nd Decon	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
<div> <div>Initial Reading</div> <div>1st Decon</div> <div>2nd Decon</div> </div> <div> <div> <input type="checkbox"/> Not Contaminated <input type="checkbox"/> Sent to 1st Decon </div> <div> <input type="checkbox"/> Decontaminated <input type="checkbox"/> Sent to 2nd Decon </div> <div> <input type="checkbox"/> Decontaminated <input type="checkbox"/> Contact Radiation Control </div> </div>			

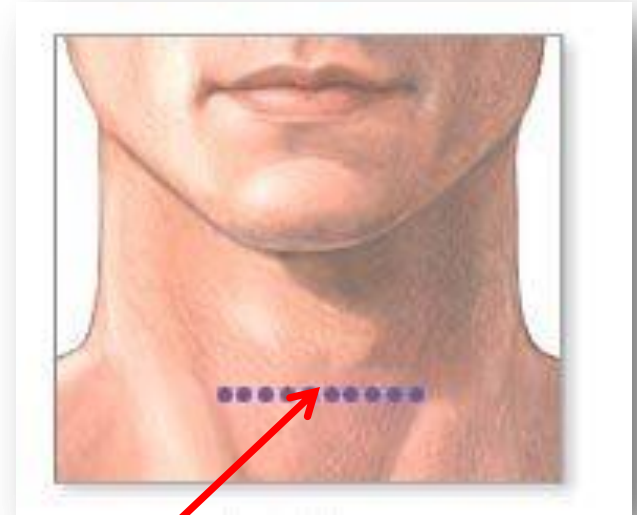
Monitor's Signature

Decon Monitor's Signature

Ludlum 14C

Surveying the Thyroid Gland

- Probe closed window
- Place probe
 - 1 inch away
 - Adams Apple
- Multiply count rate by .04
- Thyroid uptake limit (5 rem)



Radiation Dosage Limits for Personnel & Equipment Monitors

PERSONNEL/EQUIPMENT MONITORS

Radiation Dosage Limits

TEDE (Total Effective Dose Equivalent)

Monitoring evacuees/emergency workers and equipment for radiation contamination.

	<u>TEDE</u>	<u>Dosimeter</u>
Seek Relief	200 mrem	100 mR
Daily Maximum	1 rem	500 mR
MAXIMUM for ACCIDENT	5 rem	2.5 R

In addition to the above individual limits, all emergency workers are advised to make a reasonable effort to limit their total dose, while at the same time accomplishing their emergency responsibilities.

Alabama Radiation Control

Thyroid Uptake Limits

- Read dosimeters and record every 15-30 minutes.
- Seek Relief at a reading of 100 mR on your dosimeter.
- Contamination level in Alabama is (2x) twice background (shield open) and will warrant decontamination.
- Monitoring technique: 1 inch away and move 1 inch per second.
- Survey thyroid with shield in closed position.
- On lowest scale (x0.1) the Ludlum 14c meter scale will read 0-600 cpm.
- Check background and instrument operation and cover probe.
- Use CPM scale when monitoring for contamination.

Thyroid Uptake Limit

5 Rem

INSTRUMENT

CDE THYROID DOSE*

(rem/cpm above background)

Ludlum 14C (shield closed)

.04*

Multiply count rate (cpm) by *multiplier to determine committed dose equivalent (CDE) to the thyroid in rem.

Alabama Radiation Control

Portal Monitors Setting Up



Electronics
Display

Used to screen
large populations
for radioactive
contamination

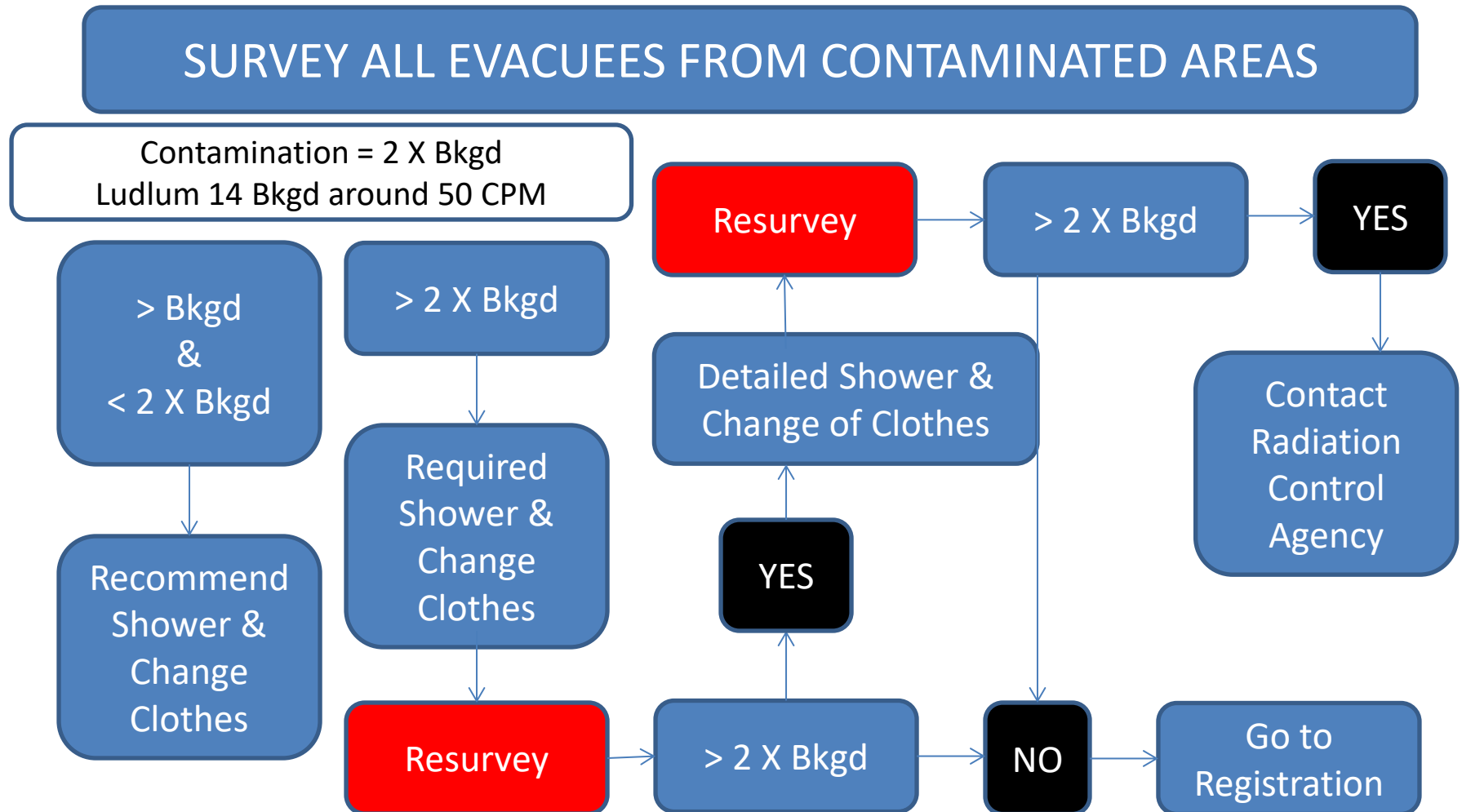


Portal Monitors

Screening for Contamination



Monitoring for Contamination Flow Chart



Personnel Monitoring Equipment

Radiation Exposure Record

Name:		SS# (last 4):	
Agency:		DOS#:	
Date: (M/D/Y)		TLD#:	
Note! Read dosimeter every 30 minutes		7/2016	
#	Time (24 hr)	Reading	Status (✓)
	Low Range	High Range	Start End Total
1			

Vehicle Monitoring/Decontamination Record

Name:		Date:	
Address:		Phone#:	
City:	State:	Zip Code:	
Year:	Make:	Model:	

NOTE: Contamination Limit in Alabama is 2 X Background
Initial survey of vehicle:

(Indicate the Location)

Front Bumper _____ CPM

Driver's Side Tire/Wheel Well (Front) _____ CPM

Passenger's Side Tire/Wheel Well (Front) _____ CPM

Roof _____ CPM

Name:

Personnel Monitoring/Decontamination Record

PERSONNEL MONITORING/DECONTAMINATION RECORD			
Name:		SSN:	
Address:		Sex: M/F	
City:	State:	Zip Code:	Phone:
Reception Center:		Date:	

THYROID DOSE			
Lutidum 14C		Adult Thyroid Uptake Limit - 5,000 mRem (5 Rem)	
(multiply CPM x .04)		NOTE: If reading 2.5 rem, escort individual to hospital for internal decontamination.	
Initial Reading:	Following 1 st Decon:	Following 2 nd Decon:	

EXTERNAL CONTAMINATION			
Note: Contamination Limit in Alabama is 2 x Background		Background Reading: CPM	
Area of Contamination (Indicate location on Diagram Below)	Initial Reading (Hairline x Dia)	Reading Following 1 st Decon	Reading Following 2 nd Decon
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Initial Reading	1 st Decon	2 nd Decon
<input type="checkbox"/> Not Contaminated <input type="checkbox"/> Sent to 1 st Decon	<input type="checkbox"/> Decontaminated <input type="checkbox"/> Sent to 2 nd Decon	<input type="checkbox"/> Decontaminated <input type="checkbox"/> Contact Radiation Control

Monitor's Signature _____ Decon Monitor's Signature _____



Electronics Display



Personnel & Equipment Training



Ludlum 14C & Portal Monitors



Glossary

- **ALPHA RADIATION** – A positively charged particle emitted from the nucleus of a radioactive element. It has a low penetrating power and has a short range - a few inches. Alpha particles are not an external hazard but are extremely hazardous when introduced into the body.
- **ALARA** – An acronym for As Low As Reasonably Achievable. An approach to radiation protection to control or manage exposures as low as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process to keep dose levels as far below applicable limits as reasonably achievable.
- **BACKGROUND RADIATION** – The radiation in the natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals. It is also called natural radiation. The average individual exposure from background radiation is 620 millirem per year.
- **BETA RADIATION** – A negatively charged particle emitted from the nucleus during radioactive decay. It has a medium penetrating power and a range of up to a few feet. Large amounts of beta radiation may cause skin reddening, and are harmful if they enter the body. Beta radiation is an external and internal hazard.
- **CONTAMINATION** – The deposition of unwanted radioactive material on the surface of structures, areas, objects, or personnel. Radioactive material in a location where it is unwanted.
- **CPM** – An acronym for counts per minute and is associated with contamination surveys. The pancake probe (44-9) with the Ludlum 14C is used when detecting for contamination.
- **DECONTAMINATION** – The reduction or removal of radioactive material from a location where it is unwanted.
- **DOSIMETER** – A portable instrument or device used for measuring and registering the total accumulated exposure to ionizing radiation. Examples are pocket dosimeter, TLD or film badge.
- **EMERGENCY CLASSIFICATION Levels** – 1. Notification of an Unusual Event (NOUE), 2. Alert, 3. Site Area Emergency, 4. General Emergency.

Glossary

- **EMERGENCY WORKER** – An individual performing duties to protect the health and safety of the public during a radiological emergency (e.g., firemen, school bus driver, police, highway personnel, medical personnel, etc.)
- **EXPOSURE** – The absorption of radiation or ingestion of a radionuclide.
- **EXPOSURE RATE** – The measure of radiation by a device (survey meter) over some time period, usually an hour.
- **GAMMA RADIATION** – A high energy photon emitted from the nucleus of an atom. It has the most penetrating power and a range of up to hundreds of feet. Gamma rays will penetrate the internal organs, therefore, they are an internal and external hazard.
- **GEIGER-MUELLER COUNTER** – A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage but no current flowing. When ionizing radiation passes through a tube, a short intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of radiation.
- **ION** – An atom that has too many or too few electrons, causing it to be chemically active; an electron that is not associated (in orbit) with a nucleus.
- **IONIZING RADIATION** – Any radiation capable of displacing electrons from atoms, thereby producing ions. Examples: alpha, beta, gamma, x-rays, neutrons and ultraviolet light. High doses of ionizing radiation may produce severe skin or tissue damage.
- **INVERSE SQUARE LAW** – The law states the gamma rays intensity is inversely proportional to the square of the distance from a point source. Therefore, doubling the distance from a point source of gamma radiation decreases the exposure rate to one-fourth ($1/4$) the original exposure rate.

Glossary

- **IONIZATION** – The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiation can cause ionization.
- **LITHIUM FLUORIDE** – A chemical compound used in thermoluminescent dosimeters.
- **KCPM** – An acronym for kilo counts per minute (thousands of counts per minute).
- **MILLI** – A prefix meaning one-thousandth (1/1000) or divides a basic unit by 1000. For example, millirem is one-thousandth part of a rem)
- **PERSONNEL MONITORING EQUIPMENT**– Devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), and pocket dosimeters.
- **POTASSIUM IODIDE (KI)** – A chemical form of stable iodine that can be used by the body to block absorption of radioiodine by the thyroid gland.
- **RAD** – An acronym for Radiation Absorbed Dose . The special unit of absorbed dose. One (1) rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).
- **RADIATION** – Is energy in the form of rays or high-speed particles. Radiation occurs naturally as in sunlight. Radiation is also manmade in the form of x-rays, medical treatments, nuclear weapons, and commercial nuclear power facilities. All forms of electromagnetic radiation make up the electromagnetic spectrum.
- **RADIOACTIVE MATERIAL** – Any material which spontaneously emits particle or photon radiation in an effort to expend excess energy.
- **RADIOACTIVITY** – The spontaneous emission of radiation, generally alpha or beta particle often accompanied by gamma rays from the nucleus of an unstable isotope.

Glossary

- **RCA** – An acronym for Radiation Control Agency.
- **REM** – Roentgen Equivalent in Man. The special unit of dose equivalent in man. It is measurement of the effect of all types of radiation on the human body.
- **ROENTGEN (R)**– A unit of exposure to ionizing radiation in air. It is radiation effect in air from x-rays or gamma rays.
- **SHIELDING** – Any material or obstruction that absorbs radiation and thus tends to protect personnel or material from the effects of ionizing radiation
- **SURVEY METER** – Any portable radiation detection instrument adapted for inspecting an area to establish the existence and amount of radioactive material present.
- **TEDE** – An acronym for Total Effective Dose Equivalent. $\text{Total Dose} = \text{External Dose} + \text{Internal Dose}$.
- **THERMOLUMINISCENT DOSIMETER (TLD)** – An extremely accurate device used to measure and provide a permanent record of exposure to radiation.
- **X-RAY** – A photon originating from the electron cloud rather than from the nucleus of an atom. One form of electromagnetic radiation. It has penetrating power like gamma radiation. X-rays will penetrate the internal organs, therefore, they are an internal and external hazard.